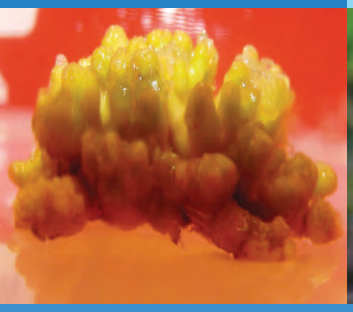
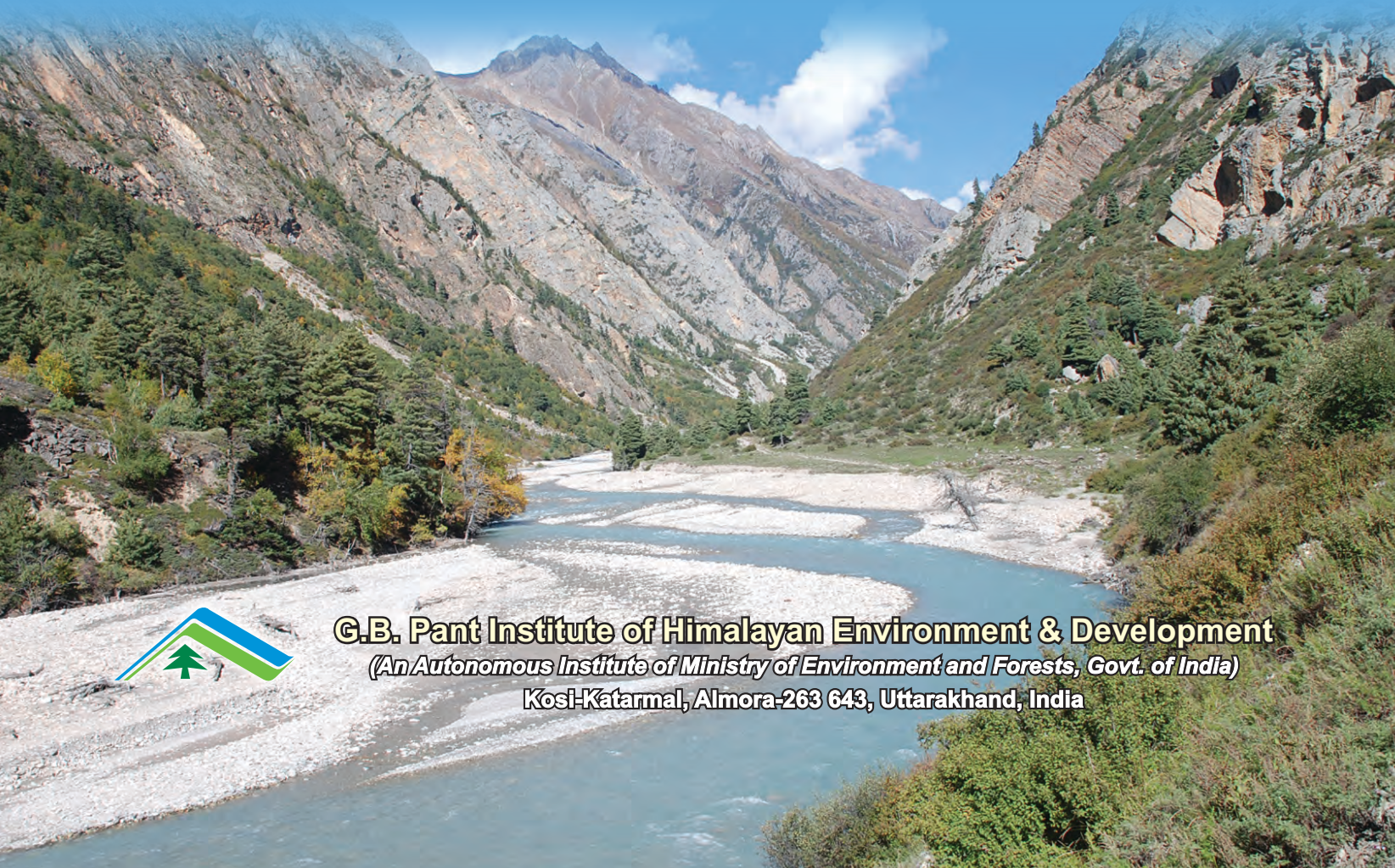


# Annual Report

2009-10




**G.B. Pant Institute of Himalayan Environment & Development**

*(An Autonomous Institute of Ministry of Environment and Forests, Govt. of India)*

Kosi-Katarmal, Almora-263 643, Uttarakhand, India

## SOCIETY

### President
Minister-in-Charge
Ministry of Environment & Forests
Government of India, New Delhi

### Vice President
Minister of State
Ministry of Environment & Forests
Government of India, New Delhi

### Members
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Chhawani Katoratal, Kashipur
Distt. Udham Singh Nagar

Shri Satyavrat Chaturvedi
MP (Rajya Sabha)
AB-92, Shahjahan Road
New Delhi-110 001

***Minister-in-charges (Environment)***

Government of Jammu & Kashmir, Sikkim, Himachal Pradesh, Uttarakhand, Arunachal Pradesh, West Bengal, Assam, Mizoram, Manipur, Meghalaya, Nagaland and Tripura

***Two MLAs from the State of Uttarakhand nominated by the Government of India***

Shri Manoj Tewari, MLA
Malla Kasun, Almora

Shri Shailendra Rawat, MLA
MLAs Residence
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Dehradun

***Five non-official members Nominated by the Government of India***

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Vice Chancellor
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Prof. Krishnamoorthy Kannan
Vice Chancellor
Nagaland University, Nagaland

***A representative of the Indian Institute of Forest Management***

Director
Indian Institute of Forest Management
Nehru Nagar, Bhopal – 462 003 (M.P.)

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Ministry of Environment and Forests, Ministry of Finance (Expenditure), Department of Science and Technology, Council of Scientific and Industrial Research, Ministry of Human Resource Development (Department of Education), Ministry of Rural Development, Department of Urban Development, Department of Non-Conventional Energy Sources, Department of Steel and Mines, Ministry of Water Resources, Department of Agricultural Research and Education, Planning Commission, Special Secretary (Conservation), MoEF, Joint Secretary (CS-1), MoEF

Chief Secretary, Government of Uttarakhand

Director General, Indian Council of Forestry Research and Education, Dehradun

Director General of Forests
MoEF, New Delhi-110 003

Director, Botanical Survey of India
Kolkata – 700 064

Chairman, Indian Council of Social Science Research, New Delhi

Director, Wildlife Institute of India, Dehradun

### Member Secretary

Director
G.B. Pant Institute of Himalayan Environment and Development,
Almora-263 643, Uttarakhand

## GOVERNING BODY (GB)

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CGO Complex, Lodhi Road,
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### Members

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Government of Uttarakhand
Dehradun

Director General (Forests)
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Additional Secretary & Financial Adviser
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Director
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Commissioner (Forests), Uttarakhand
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Scientist-D
G.B. Pant Institute of Himalayan Environment and Development,
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Dr. Satish C. Arya
Scientist-B
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### Convener

Director
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Kosi-Katarmal, Almora-263 643,
Uttarakhand

## PROJECT EVALUATION COMMITTEE (PEC)

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Scientist 'G'
Central Institute of Medicinal & Aromatic Plants
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G.K.V.K. Post Bangalore-560 065

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Dr. Sonam Dawa
Executive Director
Ladakh Ecodevelopment Group
Leh, Ladakh, (J&K)-194 101

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Itanagar - 791 109, Arunachal Pradesh

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Head
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### Representative of MoEF

### Member Secretary
(Nominee of the Director, GBPIHED)
Dr. P.P. Dhyani
Scientist 'G'/Scientit-in-Charge
IERP, GBPIHED

# Annual Report

2009-10


G.B. Pant Institute of Himalayan Environment & Development

*(An Autonomous Institute of Ministry of Environment and Forests, Govt. of India)*

Kosi-Katarmal, Almora-263 643, Uttarakhand, India

Website://gbpihed.gov.in

# CONTENT



# FOREWORD

The issues of environment and development in the Indian Himalayan region (IHR) are complex and need to be addressed in interdisciplinary and integrated manner. In this context, the Institute has made significant strides to fulfill its mandate and has created a special niche amongst National and International Research and Development oriented community. This can be judged from the fact that the Institute has actively contributed to the National Mission on Climate Change, particularly the mission on Sustaining the Himalayan Ecosystem, generating datasets on various areas directly and indirectly linked to climate change issues, and is attempting to cater to the needs of multiple stakeholder groups ranging from local communities to policy planners. The programmes and activities during the 11$^{th}$ plan period have focused on applied action oriented research, strive for greater institutional collaborations, and stakeholders involvement to increase its outreach.

During the reporting period (2009-2010), third year of the implementation of 11$^{th}$ plan, Institute has made significant progress in achieving R&D targets. Among others, strengthening of datasets on: i) water resources - following researches on optimization of hydrological responses; ii) land resources- using engineering and bioengineering measures for stabilization of landslides, and in-depth studies on glacier retreat phenomena; iii) biological resources - through multi-location response assessment studies, large scale multiplication of selected taxa following *in vitro* protocols and field transfer of propagules, and exploration of microbial biodiversity of the Himalayan soils were stressed. Also, the Institute continued to further strengthen activities related to environmental assessment and management in relation to selected hydropower projects, field demonstration trials on wasteland rehabilitation, strategies for economic development and environmental conservation in the region following alternate livelihood options. Towards promoting its outreach, Institute has focused on capacity building of a range of stakeholders through Training of Trainers (ToTs) mode on environment-friendly rural technologies through the Rural Technology Complex of the Institute at HQs, and its regional units. On-site training programmes, orientation courses, and exposure visits on biodiversity conservation, Natural Resource Management, and disaster management were other activities aimed at diverse group of stakeholders.

Among others, the Institute has been actively involved in celebrating the International Year of Natural Fibers (2009) and International Year of Biodiversity (2010) considering that the Biodiversity is an integral part of life. To celebrate the occasions the Institute has carried out and planned a number of activities during the reporting period. Many training programmes and workshops organized by the Institute were geared towards biodiversity conservation and participatory approaches. Events such as, Photo exhibition entitled "Himalayan Changing landscapes jointly with ICIMOD, Kathmandu, Fibre exhibition, National Conference on Orchids, Celebration of the International Biodiversity Day, etc. have helped in understanding the status of bioresources, threats, emerging issues and conservation approaches based on people's participation. Augmentation of infrastructure in terms of state-of-the-art instrumentation and other facilities was also taken-up. For example, establishment of the Nature Interpretation and Learning Centre, a facility for on-site training on Himalayan bioresource conservation, was initiated at 'Surya-kunj' *ex situ* conservation site of the Institute.

At the National level, Institute jointly with MoEF, Govt. of India prepared documents "Governance for Sustaining Himalayan Ecosystem (G-SHE): Guidelines and Best Practices, and "Himalayan Glaciers: A state of Art Review of Glaciers Studies, Glacier Retreat and Climate Change", which were well received. These reports form a part of India's broader climate change adaptation strategy towards governance and management of the Himalayan Ecosystem.

Acceptance of Institute's outcome by way of the publications of research articles in peer reviewed scientific journals of high repute, and financial support from different funding agencies to conduct project based research on priority issues are testimony to increasing recognition of Institute's R&D capability. The Apex bodies of the Institute continued to provide desired encouragement and guidance to the Institute to maintain the quality and quantum of its out-put and to achieve its mandate. This is gratefully acknowledged.

As Director of this premier Institute, it is my endeavor to strengthen the existing programmes and formulate new ones to realize the goals envisaged in Vision document of the Institute. I am sure, with the help of colleagues in the Institute HQs and units, as well as its well wishers out side, the Institute shall succeed in this endeavor. Your inputs and positive critique are always welcome and gratefully received.

**(L. M. S. Palni)**
**Director**

# MAJOR ACHIEVEMENTS

1. Institute contributed to National Mission on Sustaining Himalayan Ecosystem by preparing a draft Base Paper "Conservation of Himalayan Ecosystem and Adaptation/Regulation Measures" for the SEPM. The base paper subsequently formed the basis of a joint publication of MoEF and GBPIHED "Governance for Sustaining Himalayan Ecosystem – G-SHE: Best Practices and Guidelines". The document was released by Hon'ble Minister of State (I/C), MoEF on 29.9.09.

2. Institute has been entrusted with the responsibility of acting as Technical Secretariat for the Himalayan Sustainable Development Forum (Shimla Declaration) based on Himalayan Chief Ministers' Conclave held in October, 2009 at Shimla.

3. Institute contributed to the discussion paper on Himalayan Glaciers: A State-of-Art Review of Glacier Studies, Glacier Retreat & Climate Change published jointly with MoEF and released by Hon'ble Minister of State (I/C), MoEF on 09.11.09.

4. Based on the feasibility document prepared by the Institute, the Ministry of Environment and Forests has designated the Cold Desert Biosphere Reserve (CDBR) covering parts of Himachal Pradesh; on receipt of concurrence from the State Government, the relevant parts of J & K may be included in the CDBR.

5. Compilation of district level meteorological data of past 107 years (1901-2008, excluding 2003) for all states of IHR has been done. Based on second generation Hadley Centre regional climate model known as PRECIS (Providing REgional Climate for Impacts Studies), decreasing trend of rainfall has been observed both annually and seasonally during the last 30 years (1961-90) for the Upper Bhagirathi Catchment in Uttarakhand.

6. Two completed studies on Snow and Glacier Studies conducted in Tista basin in the Sikkim and Dhauliganga basin of Uttarakhand regions of IHR revealed that in the Tista basin about 2.77 % glaciated area has been deglciated in between 1997 to 2004 in 57 glaciated valleys. In the Dhauliganga basin Total loss in area of 104 glaciers from 1962-63 to 2005 was about 15.48%.

7. A horticultural model was developed by converting about 6 ha culturable community land at a representative village-Patharkot in district Almora through participatory planting of 2920 fruit plants of different varieties.

8. Generated a data base for strengthening Strategic Environmental Assessment (SEA) in two basins; the Sutlej in Himachal Pradesh and the Alaknanda in Uttarakhand.

9. Phenotypic and genotypic characterization of hyperthermophilic strains of *Geobacillus*, isolated from the hot springs of Uttarakhand.

10. Up scaling of technology dissemination and backstopping in five states of the NE region covering 49 villages and 11 tribal communities; in the process more than 1500 households have adopted one or the other technology out of the 15 low-cost and simple technologies outreached through PNGOs, who have formed 69 SHGs, 1 Marketing Committee, and 3 Farmers Club in various states.

11. Community participation in biodiversity conservation addressing critical issues such as hunting, shifting agriculture, community welfare and alternative livelihood in proposed heritage sites in Arunachal Pradesh through formation of 23 Biodiversity Management Committees.

12. Developed of morphological, chemical and molecular profile of selected medicinal plants of Himalayan region.

13. Quantification and valuation of Ecosystem Services of Pine and Oak forests were attempted for their management as vital natural resources in the Central Himalaya.

14. Environmental Observatory for Atmospheric Science and climate change studies was set up in Himachal Unit of the Institute with the latest sophisticated equipments like Surface Ozone Analyser to monitor surface ozone, other Analysers for sulphur dioxide ($SO_2$) and nitrogen dioxide ($NO_2$) measurements, Aethalometer to measure black carbon, Pyranometer to observe

for solar flux, Multi-wavelength Radiometer for obtaining columnar aerosols as aerosol optical depth, Respirable Dust Samplers for measuring particulate and gaseous pollutants.

15. Study in south-west KBR recorded 51 woody species, compared to 32 in earlier works conducted over 10 years ago; with 17 species common. Study recorded high species richness, tree density, regenerating species number, seedling/sapling regeneration, compared to previous studies. For south-west KBR, 124 *Ethnomedicinal plants*, curing 77 ailments, documented. Study further documented 77 *wild edible* plants; 54.17% species are marketed.

16. Landslide map of Sikkim has been updated using recent field visits and RS data of 2006. 229 landslide locations after field visits and 121 landslide locations using RS data have been updated in the map respectively. Landslide inventory of North District has been prepared. Landslide stabilization using engineering and bioengineering measures in the Bojeck landslide has been done.

17. Red data listing of 90 freshwater fishes of Eastern Himalayan Region following latest taxonomic nomenclature, in collaboration with IUCN (www.iucnredlist.org).

18. In vitro propagation protocol of *Rhododendron griffithianum* and *R. campanulatum* has been standardized.

**Publications:**

| | | |
|---|---|---|
| ***Peer Reviewed Journals*** | | |
| **Indian** | - | 34 |
| **Foregin** | - | 41 |
| ***Book Chapters*** | - | 45 |
| ***Popular Articles*** | - | 49 |

# EXECUTIVE SUMMARY

The institute with a strong commitment for sustainable development of the Indian Himalayan Region (IHR) is the only institute of its kind which addresses physical, biological, social and economic issues of the region and its people in an integrated manner. The R&D mandate of the Institute is broad and covers all the facets of environment and development. Towards achieving this, multi-disciplinary approach and integration are the guiding principles. The emphasis on interlinking of natural and social sciences is the major thrust of all the programmes in the Institute. In this effort, special attention is placed on the intricate balance between fragility of mountains, indigenous knowledge and sustainable use of natural resources. Design and implementation of R&D activities on priority environmental problems; development and demonstration of best practices, technology packages and delivery systems for improved livelihood of the people are the core issues covered under most programmes in the Institute. A conscious effort is made to ensure participation of local inhabitants for long-term acceptance and success of various programmes. Therefore, training, education and awareness of a variety of stakeholders are the essential components of all the R & D programmes. A brief summary of R&D activities of the Institute during the reporting year 2009-10 is as follows:

## Watershed Processes and Management (WPM)

The theme Watershed Processes and Management (WPM) focuses to work on watershed services and management, land and water use policy, consequences of climatic change, improvement of Himalayan farming systems, relevant Indigenous knowledge systems, and domestic energy needs, etc. To meet the goal of the WPM theme following R&D activities were investigated:

In project Optimizing Hydrological Responses in a functional land use model in the mid elevation Himalayan watershed- an attempt towards water sustainability mass curves analysis for available water with total domestic demand (rural & urban) indicates that cumulative available water is more than demand on annual scale. But on monthly basis ~24.3 hactare meter water shortage was recorded in April and May. During the time of water scarcity i.e. in April, May and June, water requirement of only three sectors, urban house hold, rural house hold and livestock can be fulfilled. In project Stabilization of Landslide through engineering and bio-engineering measures in Sikkim Landslide map of Sikkim has been updated using recent field visits and RS data of 2006. 229 landslide locations after field visits and 121 landslide locations using RS data have been updated in the map respectively. Landslide inventory of North District has been prepared. Landslide stabilization using engineering and bioengineering measures in the Bojeck landslide has been done.

Project Energy use pattern in rural domestic sector of Uttarakhand State – Issues, Options & Challenges revealed that among all the Himalayan states, Uttarakhand state showed highest use of solar energy for domestic lighting purposes (2% of the total households). Nearly one fourth of the total electricity consumption in the State was for domestic purpose. However, the domestic consumption has been increased in the recent years (13% since 2005). Still 13% households were exclusively dependent on firewood for cooking needs. Exclusive use of Liquefied Petrolium Gas for cooking is also visible but at a smaller scale. This shows transformation process is active but pace is slow. In project Nematode diversity in the traditional agro ecosystem of central Himalaya, correlation coefficient values indicated significant differences in rate of N-mineralization due to bacterivore and fungivore nematodes. The nematode channel ratio (NCR) of 0.79 was highest for plots planted with wheat and mustard in equal ratio indicating efficient and faster bacteria mediated channel for decomposition. This indicates that mustard cultivation with wheat is a healthy practice. Nematodes identified from *rabi* cropping (winter cropping) season belonged to two class *i.e.*, Secernentea and Adenophora.

In Development of analytical models through establishment of Modeling & Statistical Computing laboratory: an attempt towards capacity building programme compilation of district level meteorological data of past 107 years (1901-2008, excluding 2003) for all states of IHR has been done. Regular collection & management of the real time meteorological data from weather profiler installed at GBPIHED Almora is being done. For statistical analysis used in R&D work 14 research students trained for using STATISTICA software.

Project Indigenous Knowledge: traditional health care practices in rural areas of Uttarakhand found that about 75.9% *vaidyas* were male and 24.1% were woman *vaidyas.* In the family girl child is not preferred for this profession; after marriage this family knowledge shall pass to another family. Traditional *vaidyas* and villagers use about 155 plants. Ninty three herbal formulations used by the traditional *vaidyas* were documented with

their, composition, plant part used, use method and villages of their use. Out of them 83 formulation were used for treatment of human ailments and 10 were used for treatment of cattle. 15 formulations of *Tinospora cordifolia (Giloe*) have been witnessed, out of these 6 are already in literature and 9 are new. Two completed studies on Snow and Glacier Studies conducted in Tista basin in the Sikkim and Dhauliganga basin of Uttarakhand regions of IHR revealed that in the Tista basin about 2.77% glaciated area has been deglciated in between 1997 to 2004 in 57 glaciated valleys. In the Dhauliganga basin Total loss in area of 104 glaciers from 1962-63 to 2005 was about 15.48%.

Total 13 training programmes organized in the state covering 832 numbers of participants. Training models, reading material, brochures and pamphlets have been developed and distributed to trainees and visitors.

## Biodiversity Conservation and Management (BCM)

In the reporting year, Biodiversity Conservation and Management thematic group continued with two multilocational project; (i) Response Assessment and Processing of Knowledge Base to Serve Long-term Management and Use of Biodiversity in the Himalaya - Focus on Representative Protected Sites, and (ii) Up-scaling *ex situ* conservation mechanisms for conservation and sustainable utilization of high value plants. Besides, one state specific project "Conservation and sustainable utilization of medicinal plants in Himachal Pradesh" was also taken up. Under the multilocation response study project, the revisit surveys of selected sites in Nanda Devi Biosphere Reserve (NDBR), Uttarkhand revealed that at community level and across altitude range seedling and sapling layers exhibit increasing trends of species richness and density, which is indicative of likely changes in forest communities in future. At Nargu Wildlife Sanctuary (NWLS), Himachal Pradesh, 95 species of vascular plants were recorded and analysed for nativity and endemism. Besides, 37 sites were sampled between 1328-3488 m, and 22 plant communities identified. Total tree density ranged from 80-600 Ind $ha^{-1}$ and total basal area from 0.2-33.8 $m^2$ $ha^{-1}$. Study conducted at Khangchendzonga Biosphere Reserve (KBR), Sikkim recorded 51 woody species compared to earlier records of 32 from the Yuksam-Dzongri transect (south-west KBR); low species diversity index (1.07) was recorded in earlier studies compared to present value of 2.04 (close canopy) and 5.52 (open canopy) in lower forest but high species diversity (3.21) in upper forest compared to 2.8 (close canopy) and 2.5 (open canopy). Studies at Tawang-West Kameng Biosphere Reserve (proposed), Arunachal Pradesh region revealed that Monpa, Sherdukpen, Khowa, Aka, and Miji tribes depend on agriculture, horticulture, NTFPs and livestock for their livelihood.

Under the project "Up-scaling applicability of *ex-situ* mechanisms for conservation and utilization of high value plant species" focus was on (i) developing propagation protocols through seed, cuttings and tissue culture, (ii) field trials, (iii) Phytochemical investigation, (iv) genetic diversity analysis, and (v) promoting outreach through conservation education. Phytochemical analysis of *Valeriana jatamansi* showed the variation in phytochemical composition and antioxidant activity across different habitats. Genetic diversity analysis using ISSR markers revealed variation among populations. Training workshops to promote outreach through Conservation Education was also conducted at district Uttarkashi (Uttarkhand), Mandi (Himachal Pradesh), and South Sikkim and over 1100 persons from various stakeholder groups participated.

Under the project Conservation and sustainable utilization of medicinal plants in Himachal Pradesh, 57 sites in Upper Banjar valley, Parbati watershed and Mohal Khad Watershed were surveyed and sampled for the quantification of medicinal plants and associated species. Populations of 17 threatened medicinal plants were assessed and mapped. Agrotechniques, available for the 26 high value commercially viable species were disseminated to different stakeholders for promotion of medicinal plant cultivation.

Others activities included investigations under externally funded projects; (i) Expanding Outreach through Participation of Youth, (ii) Assessment and Conservation Prioritization of Plant Diversity in Himachal Pradesh, (iii) Evaluation and propagation of two vitality strengthening Astavarga plants, (iv) Population status assessment and screening of active chemical constituents, etc. strengthened the core activities of this theme

## Environmental Assessment and Management (EAM)

The Strategic Environmental Assessment (SEA) study in the Sutlej basin in Himachal Pradesh and the Alaknanda basin in Uttarakhand has shown a wide scope in systematic collection of baseline information in conducting environmental impact assessment (EIA) of individual hydropower project. Overlapping of the projects within an aerial distance of 10 km exists in either of the basins. In general, the local people were not satisfied with the existing mechanism of public hearing and overall environmental management practices being followed by the project proponents especially during construction. The

status of environmental parameters has adversely been changed from without construction stage to construction. Air, water quality and forests have mainly been among them. Solid waste study in the six towns of Himachal Pradesh has shown dominating nature of biodegradable waste over non-biodegradables which ranged from 64.7% to 78.3% in Keylong and Mandi, respectively. There is a need to practice waste to energy initiatives in the form of bio-composting. The seasonal ambient air quality studies in a land campaign mode conducted in towns such as at Bilaspur, Mandi and Keylong showed high concentration of particulate pollution compared to gaseous pollution. Many times, total suspended particles (TSP) and particulate matter ($PM_{10}$) have crossed their permissible limits as set by central pollution control board (CPCB). On diurnal basis, highest concentrations of total suspended particles (TSP) and particulate matter ($PM_{10}$) were found between 16 hr IST to midnight followed by 8-16 hr and lowest between midnight to morning 8 hr throughout the season at each experimental site. The gaseous pollutants like $SO_2$, $NO_2$ and $NH_3$ were recorded far below the permissible limits.

The ambient air quality parameters such as $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_2$ and $NH_3$ in the background sites of the hill spots at Kothi and Mohal were also monitored. The highest concentration of $PM_{10}$ at Kothi was 53.8±8.4 µg $m^{-3}$ during 8-16 hr in January 2010 and 86.03±7.3 µg $m^{-3}$ at Mohal during 16-0 hr in December 2009. However, $PM_{2.5}$ at Kothi reached 99±3.2 µg $m^{-3}$ during 0-8 hr in March 2009. $SO_2$ in maximum concentration at Kothi was 16.0±1.6 µg $m^{-3}$ during 0-8 hr in May 2009 and 7.7±0.5 µg $m^{-3}$ during 0-8 hr at Mohal in April 2009. $NO_2$ concentration at Kothi showed 5.7±0.7 µg $m^{-3}$ during 0-8 hr in April 2009. But this value at Mohal stood to be 8.2±1.3 µg $m^{-3}$ during 16-0 hr in June 2009. Aerosol Optical Depth, Black Carbon and Surface Ozone studies carried out at Mohal. Aerosol optical depth (AOD) change at 500 nm was found 54.7% from forenoon to afternoon. The variations in turbidity parameters; α and β, were inversely proportionate. The BC monitored during July 2009 to March 2010 showed hourly mean value of 2500 ng $m^{-3}$ between 6 to 9 hr IST. However, the highest ever peak values remained 15657 ng $m^{-3}$ in January 2010 at 7 hr. Diurnal variation of $O_3$ showed low concentration during morning (8-9 hr) with a peak at afternoon (15 hr) which then starts to decrease gradually (18 hr - morning 8 hr). During observation period based on frequency distribution, hourly ozone concentrations remained 7 times above 50 ppb which causes harm to human as well as plant life. Tourism study in Sikkim was synthesized for analysis of inflow trend-patterns, trend projections and its likely implications on existing infrastructure, demand-supply systems and environment. Environmental Observatory is one of the latest labs consisting of Ozone Analyser to monitor surface ozone, Aethalometer to measure black carbon, Pyranometer to observe for solar flux, Multi-wavelength Radiometer for obtaining columnar aerosols as aerosol optical depth, Respirable Dust Samplers for measuring particulate and gaseous pollutants. Besides, measuring various parameters, these latest scientific equipments have been used for demonstration purposes to awaken the different stakeholders about air pollution and climate change aspects in the state or beyond.

A representative village-Patharkot in district Almora for on-farm activity for rural income diversification was selected keeping in mind to develop a model for horticulture. About 5.9 ha culturable community land which was a wasteland was developed through planting 2920 fruit plants of different varieties. After two years in March 2010, the survival of this plantation was found to be 55%. In view of replacing this mortality, 790 saplings of different varieties of fruit plants during the reporting period 2009-10, were again planted. Then this survival was recorded 73% in March 2010.

The solid waste management technology for microbial bio-composting developed from municipal waste by the Institute has now been used for dissemination through consultative meetings and workshops in the state. The action plans/proposals as well as collaboration, based on this technology were executed for religious spots as well as trekking regions like Bijli Mahadev, and picnic spots like Rohtang Pass, Marhi and Solang *nala*. The Himachal Unit of Institute is also providing time to time guidelines and suggestions for scientific disposal of solid waste management to different municipal councils, district administrations, forest departments, etc.

## Socio-Economic Development (SED)

During the reporting period, the projects on priority areas that were initiated during XI plan period continued, i.e., (i) Smallholders farming systems: strategies for economic and environmental viability in the western Himalaya (HQs), (ii) Scaling up innovative resource management practices for improved livelihoods in the mid hills of the central Himalaya (HQs), (iii) Assessing the eco-tourism potential (Garhwal & Sikkim Unit), (iv) Shifting Agriculture: issues and options (NE Unit), and (v) Indigenous Knowledge: traditional health care practices in rural areas of Uttarakhand (HQs). Also, multilocational approach on 'Capacity building for entrepreneurship development and self employment in the Himalayan region' has continued. This year two more new inhouse projects are initiated, i.e., Pesticide residue contamination of food chain: appropriate monitoring and control

measures from field studies in Himachal Pradesh and Migration: socioeconomic and cultural implication in Central Himalaya. In addition, the group continued to work on a few externally funded projects, such as Participatory management of Bhimtal lake catchment; Institutionalizing technology backstopping and capacity enhancement for sustainable agricultural development and encouraging entrepreneurship development based on simple rural technologies within the tribal areas of north east India; Enhancement of livelihood security through sustainable farming systems and related farm enterprises in north-west Himalaya; Cultural landscape: the basis for linking biodiversity conservation with sustainable development of Arunachal Pradesh; and Biodiversity conservation though community based natural resource management in Arunachal Pradesh through externally generated funding.

The R&D projects of the Theme largely emphasized on appropriate interventions and skill enhancement of the people to enable them to develop viable, replicable and effective community based natural resource management options to effectively protect and enhance the biodiversity simultaneously improving their economy and quality of life. In principle, through R&D projects and initiatives, the group has tried to promote participation of local communities in sustainable resource management and in alternative and innovative livelihood schemes like ecotourism, agro forestry, and micro enterprises, and fill the gap in information for improving policies and knowledge base. Imparting hands-on-training on various rural and simple technologies and developing of manuals on them and translating the manuals in local dialects for effective adoption has been a well devised activity of the group. Up scaling of technology dissemination and backstopping in five states of the NE region covering 49 villages and 11 tribal communities has been carried out during the reporting year; in the process more than 1500 households have adopted one or the other technology out of the 15 low-cost and simple technologies outreached through Partner non Government organization (PNGOs) who have formed 69 SHGs, 1 Marketing Committee, and 3 Farmers Club in various states. The group has done considerable progress in ensuring community participation in biodiversity conservation addressing critical issues such as hunting, shifting agriculture, community welfare and alternative livelihood in proposed heritage sites in Arunachal Pradesh through formation of 23 Biodiversity Management Committees

## Biotechnological Applications (BTA)

In this year focus was concentrated on developing suitable propagation methods, field performance and subsequent conservation and sustainable use of economically important species of central, western and eastern Himalaya. Large scale multiplication and field plantation of *Rhododendron maddeni* and *R. dalhousiae* have continued in Sikkim. Efforts were made to standardize propagation protocols in other species using both conventional and *in vitro* methods. Studies on molecular characterization of *Podophyllum* sp. and *Ginkgo biloba* have been initiated. Alternative method of obtaining active ingredients by developing hairy root cultures of *Picrorrhiza kurrooa*, a high value Himalayan medicinal plant was achieved under laboratory conditions, and indicated positive results; this has commercial implications and would reduce the pressure on natural population.

Exploration of microbial diversity with specific reference to plant growth promoting microorganisms and mycorrhizal associations comprises another important aspect and is being carried out in Himalayan soils, including north-east region of India. Rhizosphere populations associated with different age groups of *Ginkgo biloba* were investigated. Besides colonization of free living microorganisms and arbuscular mycorrhizae, occurrence of endophytic organisms, got attention. A large number of *G. biloba* plants were raised using bacterial (isolated from cortical cells of the plant) based broth formulation, under net house conditions. A new investigation on microbial communities in river Jataganga (Jageshwar, District Almora) during festival and different seasons has been initiated. Among extremophiles, species of *Streptomyces* (cold tolerant) and *Aspergillus* (cold and pH tolerant) have been investigated for their antagonistic and enzymes producing properties. Field assessment of microbial inoculants yielded positive results and is being continuously monitored on a long term basis. A new DST funded project has focusing on determining the phosphate solubilization and litter decomposition potential of the dominant fungi, isolated from the Himalayan soil has been initiated. Studies on diversity and reproductive habits of fishes in relation to environmental parameters of Senkhi River in Arunachal Pradesh is continuing; among the various species available in the river the most successful in terms of catch frequency is *Barilius bendelesis*. Initiatives on capacity building for rural folks and training of students for (MSc & PhD) continued. Under the pond-based integrated farming system, two new sites were developed in the Kumaun region; such initiatives have not only resulted in more income for rural women but also set up demonstration of technologies for the region.

## Knowledge Product and Capacity Building (KCB)

Fibre based products were developed from *Hibiscus cannabinus* (threathened bioresource of the region) for

promoting its conservation and household level enterprise. The traditional uses and cost-benefit analysis of agronomic practices were worked out. About ten (10) youth of the two village's i.e . Shrishi and Triyuginarayan have adopted the home-stay accommodation and they are now well familiar with the concept of home-stay accommodation. Very recently a exposure visit was organized for the youth involved in home stay accommodation from 5th to 8th March 2010 to village way (Almora) to provide them more insight and tips in the above field. Strengthening fodder resources and developing model through indigenous, fast growing and high biomass yielding plant species on 4 ha village common degraded land at Maikhanda village in upper Kedar valley for reducing drudgery of women. A small processing unit has been established for making various value added products from wild, domesticated and semi-domesticated edible plants/crops at participatory rural technology centre at Triyuginarayan.

In-depth study was conducted to assess the stakeholder's response to helicopter services to Kedarnath Dham and its impacts on local economy (particularly on dandi-kandi, pack animals operators/owners etc.). Developed tourism/eco-tourism knowledge network involving different institutions working on eco-tourism/tourism related issues for knowledge sharing. In-depth study on traditional health care system was carried out in high altitudinal region of Alaknanda catchment which revealed that about 400 plant species are being used by Vaidhyas or local healers for curing about 135 ailments. In addition, 150 Vaidhyas were consulted and interactive discussion was held with them to know their perceptions and attitude on weakening and possible option for the development of traditional healthcare system. Studies on traditional grain legume crops of the central Himalaya in relation to changes in temporal and spatial diversity, socio-cultural, traditional ecological knowledge, ethno-medicinal and neutraceutical properties, uses and agronomic practices were carried out. Inventory of macro and mesofauna in different landuses systems in Nanda Devi Biosphere Reserve were carried out under TSBF/GEF/UNEP project. Assessment of abundance and diversity of vesicular arbuscular mycorrhizal (VAM) fungi and legume nodulating (LNB) Bacteria across a gradient of land use types in Nanda Devi Biosphere Reserve were carried out. A change in calendar for pastoral migration from alpine to foothills forests has been recorded and attitudes of this change have been identified.



# 1. INTRODUCTION

The year 2009-10 is twentieth financial year of R&D activities being executed by the Institute at different locations of the Himalaya through its HQs at Kosi-Katarmal (Almora) and four regional Units, namely, Himachal Unit (Kullu), Garhwal Unit (Srinagar-Garhwal), Sikkim Unit (Pangthang) and NE Unit (Itanagar). Over the years, the Institute has taken significant strides in identifying problems, developing region specific approaches, demonstrating their efficacy in the field and disseminating information to various stakeholders. The diverse problems thus addressed were related to ecology, resource conservation, traditional practices, livelihood opportunities, land restoration, propagation protocol development, biotechnological interventions, etc. The Institute implements its activities through core funds provided by the Ministry of Environment and Forests (MoEF), Govt. of India, and the projects financed by external funding agencies (National and International). The Institute also supports activities of various partner Institutions in different Himalayan states through Integrated Eco-development Research Programme (IERP). The Science Advisory Committees of the Institute reviews the progress of existing projects and provides guidance to develop new R&D programmes. Under the provisions of GBPIHED VISION -2015 and following the stakeholders' consultations across the region, including that of the Scientific Advisory Committee, the Institute has developed a perspective plan for XI plan period (2007-12). The identified thematic categories include the following: (1) Watershed Processes and Management (WPM); (2) Biodiversity Conservation and Management (BCM); (3) Environmental Assessment and Management (EAM); (4) Socio-economic Development (SED); (5) Biotechnological Applications (BTA) and (6) Knowledge Product and Capacity Building (KCB).

During the reporting period various activities/projects were concluded. Summaries of these are included at appropriate places in the text. In due course detailed documents will be published and made available to the public. The progress made during the year 2009-10 on various in house and externally funded projects under different thematic groups, a brief account of academic and other activities, along with the statement of accounts, have been presented in this report. The Institute would be most grateful to receive critical comments and suggestions for the improvement of its activities of research & development



# 2. MILESTONE EVENTS

## Society Meeting

The 15th meeting of the G.B. Pant Society of Himalayan Environment and Development (GBPSHED) was held under the chairmanship of Shri Namo Narain Meena, Hon'ble Minister of State, Environment and Forests, Government of India, on 11th May, 2009.

Among other members, Shri Satyavrat Chaturvedi, Hon'ble Member of Parliament (Rajya Sabha), Shri B.S. Parsheera, Additional Secretary (CS), Ministry of Environment and Forests, New Delhi, Dr. B. P. Nilaratna, Joint Secretary, Ministry of Environment and Forests, New Delhi, Dr. R.R. Rao, Emeritus Scientist CIMAP, Bangalore, Shri S.K. Pande, Ex Director General (Forests) and Special Secretary, Ministry of Environment and Forests, New Delhi, Prof. K. Kannan, Vice Chancellor, Nagaland University, Nagaland, Prof. I.A. Hamal, University of Jammu, Jammu (Representative of VC), Shri A.K. Bhandari, Advisor, TPPC, Ministry of Mines, New Delhi, Shri S.K. Srivastava, Sr. Joint Commissioner, Ministry of Water Resources, Dr. D.K. Singh, Additional Director, Botanical Survey of India, Kolkata, Dr. A.K. Gogoi, ADG (Agril), ICAR, Dr. G.S. Rawat, Deputy Director General, ICFRE, Shri Anup Wadhawan, Secretary Forests, Govt of Uttarakhand, Shri R.K. Gupta, Conservator Forests, Govt of Mizoram, Shri Vivek Saxena, IFS, Director (CS), Ministry of Env. and Forests, New Delhi and Dr. L.M.S. Palni, Director, GBPIHED attended the meeting.

## SAC Meeting

16th Meeting of the SAC of the Institute was held on May 18-19, 2009 under the chairmansip of Prof. Jayanta Bandyopadhyay, Indian Institute of Management, Kolkata. Mr. N.S. Napalchyal, Dr. B.R. Arora, Prof. I.A. Hamal (Special Invitee), Dr. R.K. Maikhuri, Dr. K.K. Singh, Dr. S.C. Arya were other GBPIHED members present in the meeting. The meeting started with welcome address by Director of the Institute, Dr L.M.S. Palni and confirmation of minutes of XVth SAC Meeting. Following the opening remarks of the chairman SAC, Dr. Palni made a brief presentation on the progress of the Institute during the year. This was followed by individual presentation by the scientist on the inhouse projects. The members of the SAC keenly observed and

discuused on the 5 years rolling plans of each project. Besides, a brain storming on thematic areas, integration of activities/future directions was given by the SAC member under the chairmanship of Prof. Jayanta Bandyopadhyay.

## International Biological Diversity Day

International Day for Biological Diversity was celebrated at the Institute HQs and all four regional Units of the Institute under the theme entitled "Causes and Impacts of Invasive alien species" (May 22, 2009). On this occasion, Dr. L.M.S. Palni, Director, GBPIHED focused on the impacts of alien species on Himalayan biodiversity. To celebrate this occasion a programme was organized at the Institute's Arboretum "Suryakunj" particularly for the school childeren of Kumaon region, emphasizing on the threats posed by alien and invasive species and its control. A total of 56 students along with 11 teachers participated. Several competitions, like drawing, creativity assessment, group discussion, quiz and extempore speech were conducted for the school children. Dr. L.M. S. Palni, Director deliberated the closing remarks and encouraged the school children for active participation and in their efforts towards conservation of biodiversity in the Himalaya.

At Garhwal Unit the day on was celebrated with the exposure to participants on the ongoing research activities of the unit and emphasised on Alien Invasive Species and its diversity and encroachment in wild and agriculture and their hazardous impact on biodiversity, economy and health also. Participants discussed and shared their views and experience on biodiversity conservation. 35 students and teachers from various educational schools and institutes of Srinagar, Garhwal and scientists of the institute along with research scholars ensured their participation.

## District Disaster Management Plan

A five days training jointly programme organized (June 1-5, 2009) by Disaster Management Faculty of Sikkim Unit of the Institute with National Institute of Disaster Management, New Delhi and Land Revenue and Disaster Management Department, Government of Sikkim. Emphasis was made on the preparation, revision and creation of District Disaster Management Plan in the state for effective coping with the disaster related issues. A periodical upgradation/revision of district plan to minimize any mishaps was recommended in the training programme. A senior to middle level officers from various line department of the state were participated in the training programme. A total of 32 participants from state and central Government organizations comprising of engineers, architects, geologists, researchers, foresters, and NGOs etc. participated in the training programme.

## World Environment Day

The Institute at its Hqs. celebrated World Environment Day- 5th June, 2009 as "A day with the students". The main theme of the day was "Combating Climate Change in Himalaya". About 300 students from different schools participated in the event. The main aim is to familiarize students to primary and secondary classes with Institute activities and to conduct them with various laboratories. Garhwal Unit celebrated World Environment Day with a theme *Combat Climate Change* on 05 June, 2009. Scientist Incharge of the Unit depicted a brief presentation on the on going R & D activities of the unit and emphasised more on impact of climate change on different component and its mitigation strategies. The participants were also awared and motivated towards environmental conservation while imparting training through demonstration and poster. During this important event about 35 students from various educational institutes of Srinagar, Garhwal and scientists of the institute along with research scholars ensured their participation.

At Sikkim Unit the day was jointly celebrated with the Department of Forests, Environment and Wildlife Management Department (FEWMD), Govt. of Sikkim. The day-long programme was hosted at the Pangthang Junior High School premises with focus on slogan of the year – "Save the planet earth – unite to combat global warming". A group of large number of school children, teachers and stallholders, villagers and dignitaries from various State and Central Government Departments and the staff of GBPIHED, Sikkim Unit participated during the event. At the end a large number of high quality, tissue culture and nursery raised, rare and threatened Rhododendron spp e.g. *R. maddeni*, *R. griffithianum, R. baileyii, R. dalhousiae* and *R. ciliatum* developed by GBPIHED were planted with active participation of local folk, especially village women, personnel from the Forest Department and GBPIHED.

## UPROBE Teachers Training and Workshop

A three days training workshop (August 10-12, 2009) was organized at Govt. Inter College, Dhaulcheena (Almora) for the selected schools working under U-PROBE project. Representatives of 17 schools (teachers 19 and students 41) from four districts (Almora, Pithoragarh, Champawat and Bageshwar) were participated. In addition, three identified school teachers along with the Institute representatives acted as resource person

during the programme. Besides training on different modules (i.e., introduction, assessment, value and value addition, conservation and linking biodiversity with other environmental issues) such as climate change, land and water management were also deliberated. Participants were exposed with different demonstration models in order to give practical exposure on the subject matter.

## Annual Day Celebration

The 122th Birth Anniversary of Pt. Govind Ballalbh Pant and Annual Day function of the G.B. Pant Institute of Himalayan Environment & Development Institute (GBPIHED) was celebrated on 10th September 2009. Inaugurating the function the Chief Guest, Dr. V.P. Arora, Vice-Chancellor, Kumaun University, Nainital paid his tribute to Pt. Pant. The special guest of this function Prof. V.K. Gaur, FNA, Centre for Astrophysics, Bangalore delivered the inaugural address on Climate Change and Green House Gases Mitigation Issues.

At this occasion the 15th Pt. Govind Ballabh Pant Memorial lecture entitled, "*The italics Legacy of Govind Ballabh Pant: Mountain and Rural Development Issues*" was delivered by Dr. R.S. Tolia, IAS, Chief Information Commissioner, Govt. of Uttrakhand and former Member of Governing Board of GBPIHED. Through his well researched lecture he enlightened the audience about the contributions of Pt. Pant on forests and rural development related issues of mountains and other parts of the nation as well. He suggested that the Institute must start a Pt. Pant Chair and Fellowship to investigate upon his work done during British Raj and to turn them into reality for the betterment of hill people and environment. In his welcome address, Dr. L.M.S.Palni, Director of the Institute briefly mentioned the Institutes" R&D activities operated through its HQs at Kosi- Katarmal, Almora and through the four regional Units (Kullu-Himachal, Srinagar-Garhwal; Pangthang-Sikkim and Itanagar-NE). He emphasizes upon the Institute's commitment on promoting and up scaling the environment- friendly and cost- effective technologies in the region. In her presidential address, Ms. Radha Behn, Laxmi Asmram, Kausani, and President, Gandhi Peace Foundation, New Delhi stressed upon the transfer of scientific knowledge to the benefit of common people.

At this occasion, a photo stall entitled, "Himalaya-Changing Scenario" was also inaugurated by chief guest of the function, Prof. Arora, and an exhibition on "International Year of Natural Fibre" by Prof. V.K. Gaur. This exhibition was continued for next 3 days. A photo exhibition on ""Changing scenario of Himalaya jointly by ICIMOD and the Institute was also stalled by the Institute at this occasion wherein rare photographgs of 1950 till 2007 donated by the ICIMOD were displayed. At this occasion an Institute booklet entitled, "Integrated Fish Farming" was also released by Dr. Tolia. Vote of thanks was proposed by Dr. P.P. Dhyani, Senior Scientist of the Institute. Besides, the main function of the Institute HQs, Kosi-Katarmal, Almora, Annual Day was simultaneously celebrated at all the four regional units (HP Unit, Kullu; Garhwal Unit, Srinagar; Sikkim Unit, Pangthang and NE Unit, Itanagar).

## Photo/Fibre Exhibition

On occasion of Institute Annual Day on 10th September 2009 and considering the importance of International Year of Natural Fibres, the Institute organized a three day exhibition from 10-12th September 2009 on Natural Fibres in order to create awareness among the people on the use of natural fibres in the Indian Himalayan region (IHR). The exhibition was inaugurated by Prof. V.K. Gaur, Indian Institute of Astrophysics and the Centre for Mathematical Modelling and Computer Simulation, Bangalore on 10th September 2009. Over 100 natural fibre products obtained from 13 plant species were displayed in the exhibition hall of the Institute. The materials were acquired from the staff of GBPIHED working at the Headquarters and in different units. The visitors took keen interest and looked at the various natural fibre products. During the exhibition, the representatives of the Institute explained the need and importance of natural fibres.

## Wild Life Week Celebration

On the occasion of Wildlife Week (October 2009), Institute organized a Biodiversity exposure and interpretation campaign for students and teachers of Almora District. The aim of the campaign was to make aware the youth (school children and teachers) on Biodiversity Conservation. Particular emphasis was given on inculcating interest among the children for diversity of life in their immediate surrounding. Exposure visit to the 'Suryakunj' - Nature Interpretation and Learning Centre established within the Institute Campus at Kosi-Katarmal, Almora was the main event, which was followed by various on-spot competitions for the students. A total of 100 students and 19 teachers from 15 schools participated in the programme.

## Training for Promoting Conservation Education

A three days training workshop (October 12-14, 2009) for promoting conservation education among the school children was organized at G.I.C. Matli (Uttarkashi). The main focus of the event was to create awareness about the contemporary issues on biodiversity assessment and its conservation. During training workshop 34 teachers and 75 students (from 33 schools) participated. Workshop included different modules (i.e. introduction, assessment, value and value addition, conservation and linking biodiversity with other environmental issues, i.e. climate change, water and land) including practical work on various methods of biodiversity assessment through field

visit to the natural sites.

Similarly, two training programmes were organized in Government Senior Secondary School, Goshal, District-Kullu (October 22, 2009) and Government Senior Secondary School, Ghumarwin, District- Bilaspur, HP (October 28, 2009) on "Weather Monitoring, Climate Change and Biodiversity". The Resource Persons delivered the lectures on Biodiversity in relation to Climate Change; Air Pollution and Climate Change; Demonstration of Weather Monitoring and Data Collection. Qualitative and quantitative assessment of biodiversity was also done during the training. The Participants were given exposure of Historical Transect Analysis, resource, social and transect mappings, information generation of the natural resource utilization patterns, cropping patterns, land use pattern, climate change, etc. and a participatory rural appraisal was conducted in these villages. Similarly, on March 19-20, 2009 a training on Conservation Education was organized by the Sikkim Unit of the Institute. The training consisted of pictorial presentations, lecture of subject experts, exposure visit to laboratories and nurseries eapecially field excretses in the semi-natural habitat in arboretum of the Institute.

## Training on Molecular Biology

Hands on training on 'Techniques on DNA fingerprinting' had been organized by Biotechnological theme of GBPIHED in Kosi, Almora from 26th October to 30th October 2009. In this training Ph.D scholars and scientist were participated to know the basic technique used in DNA fingerprinting including DNA isolation, restriction digestion, PCR, and DNA profile analysis. Training was inaugurated by Dr LMS Palni (Director, GBPIHED) and an inaugural lecture was given by Dr BD Lakhchaura (Dy. Director, Devasthali Vidhyapeeth) on General view on DNA fingerprinting techniques and applications. Lectures were also given by Dr PK Agarwal (Head, Crop Improvement Division, VPKAS, Almora), Dr SK Nandi (Group Head, BCM and BTA theme) and Dr Shilpi Paul (Scientist, Molecular Biology).

## Farmers Meeting on Medicinal Plants

The Institute in collaboration with Herbal Research and Development Institute (HRDI) organized two days meeting on cultivation of medicinal plants (October 27-28, 2009). The meeting was inaugarted by Dr. L.M.S. Palni, Director, GBPIHED and emphasized on the cultivation of medicinal plants for fulfilling the requirement of raw material availability for pharmaceutical industries. Dr. R.C. Sundriyal, Director, HRDI made a presentation on the progress of the work carried out at HRDI and highlighted different schemes of Govt of Uttarakhand on the medicinal plants cultivation. He assured that HRDI will support the progressive farmers involved in the medicinal plants cultivation. During the meeting, scientists from various Institutes delivered lectures on different aspects of medicinal plants cultivation and sustainable utilization. Over 50 farmers from different areas of Kuman and Garhwal Himalaya participated in the meeting.

## Photo Exhibition on Climate Change in Himalaya

Organized a two days Photo Exhibition on Himalaya: Changing Landscape at Garhwal Unit, Srinagar Garhwal, between 6-7 November 2009. Mr. R. S. Negi, I G, SSB Academy, Srinagar Garhwal was the chief guest of inaugural session of the programme. About 500 participants from different departments i.e. university, colleges, shools, ITI, Medical and army participated in the programme. Similary, the exhibition was organized at HP Unit (2-3 November, 2009) at Kullu.

## Nature Science Activity Camp

In a DST sponsored programme, a seven days "Nature Science Activity Camp" was organized for the students and teachers by the Himachal Unit of this Institute (November 10-16, 2009). The participants were exposed to impact of climate change on horticultural crops, biodiversity of Himachal Pradesh, plant identification, quantification and status assessment, protected areas, etc. Besides theoretical deliberations, an exposure vist to arboretum, laboratories, library, herbal garden, etc were made. Excursion to Doharanala herbal garden, fish farm maintained by the Institute and villages and information generation on natural resources were also made. Wildlife of Himachal Pradesh with special reference to avifauna was taught to the participants. They also visited demonstration of solid waste management techniques and air pollution monitoring stations. In this event over 50 teachers and students representing 10 schools of HP participated.

## Annual Day of the Campus School

The Campus School of the Institute celebrated the Annual Function on 14th November, 2009 on occasion of Childeren's Day. The children of the school presented various colourful programmes, such as grop songs, poems, spits, etc. The teacher-in-charge presented the Annual Progress of the school. The chief guest, Director of the Institute presented prizes to the children for their performance in the areas of studies, sports and other competitions. The Annual Magzine of the school prepared by the children and teachers was released by the chief guest. Over 100 participants including guardian and school children, Institute faculty and other guests were present at this occasion.

## Training Programme on Capacity Building on Rural Technology

Three training programme (each of three days) on "Capacity building in the area of simple rural technologies for livelihood improvement" were organized for the

stakeholders/farmers from three districts i.e. Tehri Garhwal, Chamoli Garhwal and Bageshwar selected by Uttarakhand Parvatiya Aajeevika Samvardhan Componey (UPASaC), Govt. of Uttarakhand (November, 2009). 90 participants from different district were participated in these programmes. Participants were exposed to details technical know how the simple rural technology and appropriate methods of harnessing of natural resource available locally.

## Workshop on Strengthening Fodder Resources

Two one day capacity building workshops were organised in village Maikhand under DST (SYSP) funded project entitled "Strengthening fodder resources and developing a pilot model for reducing drudgery of rural women in Kedarnath Valley, Uttarakhand" (29/01/10 and 30/03/10). Local activist Sri. Raja Ram Semwal chaired the workshop sessions. Vinod Ghildiyal, Malupani, District Tehri Garhwal, Dr. Lakhpat Singh Rawat and Dr. Deepak Dhyani delivered lectures on the fodder problem and appropriate measures to combat fodder scarcity in Upper Kedar valley. Introduction of fast growing, high biomass yielding fodder trees were suggested and *Morus alba* (50) and *Pennisetum purpureum* Hybrid Napier 2 varieties (1500 shoots) were distributed to the villagers of the area.

## Governing Body Meeting

The 34th Governing Body Meeting of G B Pant Institute of Himalayan Environment and Development, was held on February 22, 2010 at the Ministry of Environment & Forests, New Delhi, under the Chairmanship of Sh. Vijai Sharma, Secretary, Ministry of Environment & Forests, New Delhi. The meeting was attended by Shri P.J. Dilip Kumar, DG Forests & SS, MoEF (Member), Shri Hem Pande, Jt. Secretary, MoEF (Member), Shri S. Jagannath, Director IFD, Nominee of AS & FA (Member), Prof. V.K. Gaur (Member), Prof. S.K. Sopory (Member) and Dr. L.M.S. Palni, Director (Member Secretary).

Other Members, Secretary, DBT, New Delhi; Chief Secretary, Uttarakhand; Additional Secretary, MoEF; Prof. Kanchan Chopra; and Prof. J.S. Singh could not attend the meeting and leave of absence was granted to them. However, inputs received, through eMail, from Prof. J.S. Singh and Prof. Kanchan Chopra were tabled. Shri Vivek Saxena, Director (CS), MoEF also attended the meeting. The Governing Body approved the draft Annual Report and statements of the Accounts for the year 2008-09.

## Workshop on Traditional Health Care System

Two days workshop on contribution of medicinal plants in traditional healthcare system was organized by the Garhwal Unit of the Institute at Participatory Demonstration and Action Research Training Centre, Triyuginarayan, Rudraprayag (25-26 February, 2010). A total of 40 participants (traditional V*aidyas*, local people, scientists, medical doctors Govt. and NGOs) actively took part in the workshop of which 15 participants were traditional *Vaidyas*. The workshop began with an inaugural session with introductory remark and welcome of the participants by Dr. R. K. Maikhuri, Scientist In charge of the Institute. Dr. R. C. Sundriyal (Director Herbal Research and Development Institute Gopeshwar) was the chief guest of the function. He expressed the need to format Vaidyas association for effective management protection. The major objective of the workshop was to serve as a platform for exchange and sharing of traditional knowledge among the *Vaidyas* of different regions, resource persons and stakeholders likely to be benefited by this system.

## Training on Earthquake Resistant Buildings and Retrofitting

A two day training programme organized by Land Revenue and Disaster Management Department, Government of Sikkim in collaboration (March 1-2, 2010) with Disaster Management Faculty of Sikkim Unit of the Institute. The present building structures in Sikkim state were discussed and retrofitting and earthquake resistant building structure design suggested. The target group of the programme was town planner, architect and engineers from various departments of the state and a total of 70 participants were participated in the training programme.

## Workshop on Promoting Ecotourism

Garhwal Unit organized a two days workshop on promoting ecotourism and biodiversity conservation in upper Kedar Valley (19-20 March, 2010). Padamshree Chandi Prasad Bhatt was chief guest and Prof. D.R, Purohit, Director Folk and culture department, HNB Garhwal University Srinagar was special guest of the programme. Scientist Incharge welcomed the participants followed by detail presentation on problem, issues and management of eco-tourism in Kedar Valley. Stakeholders put their views and problems induced during tourist season, total of 80 participants from excutive members dignitary of KEDAR (Kedar Ghati Ecotourism Development Action and Research) association, Govt departments, NGOs, women farmers, different stakeholders participated in the programme.

## National Conference on Orchids

To celebrate the International Year of Biodiversity 2010, the Institute organized a "National Conference on Systematic and Diversity Analysis for Conservation and Sustainable Utilization of Orchids", jointly with The Orchid Society of India (March 19-21, 2010). In this Conference appropriate measures for effective conservation and sustainable use of orchids were recommended. Besides,

it was suggested that orchid based vocations need to be initiated especially for women and unemployed youth considering the potential of orchid diversity in the Indian Himalayan Region. The conference was attended by over 60 participants from various Research Institutions, Universities, Forest Department, and non Government organizations. Among others, Dr. Manju Sharma, Former Secretary, Department of Biotechnology and President of The Orchid Society of India, Prof. H.Y. Mohan Ram, New Delhi, Prof. A.K. Bhatnagar, University of Delhi, Prof. Pradeep Chandra Deka, Vice-Chancellor, Sir Padampat Singhania University Udaipur, Prof. S.R. Rao, North Eastern Hill University, Shillong, Dr. J.S. Rawat, IUCN India Office, New Delhi, Mr. Manoj Chandran, IFS, Pithoraharh, Dr. Anil Sood, Scientist, IHBT Palampur, and many others participated in the Conference.

# 3. RESEARCH AND DEVELOPMENT PROGRAMMES

## Group: Socio Economic Development (SED) & Environmental Assessment and Management (EAM)

The unique environmental setting of the Indian Himalayan Region (IHR) is varied owing to ecological, socio-economic and cultural diversity. Traditionally, the system is strongly rooted upon the concept of recycling of resources within; however, the system is undergoing rapid breakdown because of the population pressure and developmental needs. In view of the above, Socio Economic Development (SED) theme of the Institute focuses on identified activities such as livelihood enhancement, sustainable tourism, entrepreneurship and self employment, indigenous knowledge, and migration and its socio-economic and cultural implications, etc. The development in the IHR so far has also involved conflict between man and nature. The exploitation of the large resource base of the hills by urban industries through mining, large scale timber extraction or hydro-electric power generation from the hill streams and rivers have resulted in both positive and negative side effects. Environmental costs of such developmental interventions, therefore, need to be integrated with traditionally practiced cost-benefit analysis. Identification of strategies for ameliorating environmental threats through scientific assessments and looking at alternate pathways for securing the ecologic and economic security of the IHR are, therefore, the back bone of the Environmental Assessment and Management (EAM) theme of the Institute, which focuses on activities such as hill specific Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA), aerosols and climate change impacts, disaster mitigation and management, and environmental management of urban areas, etc.

## Group: Watershed Processes and Management (WPM) & Knowledge Products and Capacity Building (KCB)

Land and water form the backbone of the resource base on which agriculture, forestry and animal husbandry linkages depend. To meet the Millennium Development Goals for reducing hunger, combating water scarcity and achieving environmental sustainability, it is vital to seek methods for using watershed services more efficiently without compromising with the environment. In the Himalayan context, the challenges are even bigger due to complexity and fragility of the mountain ecosystem. To address some of these challenges in an integrated time bound manner, this group focuses on studies of ecosystem processes operational at watershed level including involvement of user groups and upstream-downstream linkages with a specific target of strengthening mountain specific resource management practices in a systems approach. This group also envisages activities on the enhancement of Institutional outreach based on its research products such as state-of-art methodologies/approaches, models and policy briefs, etc. Besides the above, capacity building through specifically designed modules, trainings programmes, library and IT services, which also help significantly in human resource development, are the other core areas of the R&D activities of the Institute.

## Group: Biodiversity Conservation and Management (BCM) & Biotechnological Applications (BTA)

The importance of biological resources for human welfare is tremendous and beyond question since early times. With increasing human population and demand for bioresources, its sustainable and judicious use is essential for the long time survival of the people of the entire world and particularly those in the Indian Himalayan Region, which covers a total geographical area of approximately 591, 000 km$^2$ (18% of India) and is inhabited by about 3.7% of the total population of the country. This region harbours a variety of plant, animal and microbial populations, and is considered a “hot-spot” of biodiversity; it also caters and contributes significantly to supporting livelihood and contributing to the economic well being of the people. However, the changing world scenario stresses the need for increasing food production, pharmaceutical and other products, along with heavy industrialization, which has compelled biologists to contemplate on serious issues, like conservation of biodiversity, climate change, biotechnological interventions for improved productivity, etc. The group focuses on aspects of biodiversity conservation and management, and on applications of biotechnological methods for improving the rural economy of the Indian Himalayan Region.

## Theme

# WATERSHED PROCESSES & MANAGEMENT (WPM)

Himalayan watersheds support varieties of managed and natural land use types such as terraced farming, agroforestry and orchards in north west and central to jhum farming in north east Himalayan regions. Besides these, natural forests, pastures, degraded lands, glacier and snowbound regions a re other important land uses that regulate watershed processes. The recently accepted UN Millennium Development Goal targeted to reduce by half the proportion of people without sustainable access to safe drinking water and reduce hunger. The theme activities include problem identification, assessment and quantification of ecosystem processes through synthesis of research findings and development of practices/packages for implementation with the involvement of beneficiaries. The theme focuses to work on watershed services and management, land and water use policy, consequences of climate change, improvement of Himalayan farming systems, relevant Indigenous knowledge systems, and domestic energy needs, etc. The main objectives of the theme are: to study the dynamics of the watershed processes and evaluation of ecosystem components on a watershed scale; to develop ways and means of optimal uses of watershed services for improved economic and ecological viability, and evolve strategies for efficient utilization of resource through integrated watershed management.

### Optimizing Hydrological Responses in a Functional Land Use Model for Mid-elevation Himalayan Watersheds: An Attempt towards Water sustainability *(2007-2012, In-house)*

This project focuses on interface of water demand & availability, major land uses (forest land, agriculture/ waste land and urbanization) for water sustainability in the fragile Himalayan watersheds. Optimizing water allocation for different competing uses within a watershed is being attempted to build functional land use model for a populated mid-elevation watershed in Central Himalaya. The study is conducted in the northern part of the Kosi basin (upper Kosi watershed between 290 30' and 290 55' N Latitudes and 790 30' and 79045' E Longitudes covering 364.18 km2 area) spreading over the Lesser Himalayan domain and administratively within district Almora, Uttarakhand state. The absolute relief of the catchment ranges between 1080m and 2720 m from the mean sea level. Other study area Taktsom Chu watershed in Sikkim is selected for replicating the output with required modification. The Taktsom chu is a tributary of Rani Khola, lies in Teesta basin. The Taktsom chu watershed is situated at the south-eastern part of the state in the East district. It extends from 27015' to 27020' N and 88037'30" to 88042'30" E, embracing an area of 35.42 km2.

#### Objectives

- To analyze policies and practices of land use (forest and non-forest land), land transformation (one land use category to other) and related water use in selected watersheds.
- To quantify hydrological processes and establish functional relationship of land use changes and hydrological responses in social and climate change scenario.
- Development and demonstration of functional land use model using optimized hydrological response (water allocations) at sub-watershed level.
- Disseminations of an adaptive land use policy and integrated decision support system for water resource management at watershed level.

#### Achievements

- Geological map of Upper Kosi watershed has been prepared. The whole Kosi watershed consists of mainly Almora crystalline with gneisses and schists. The Almora crystalline zone consists of garnetiferous schists with interbedded flaggy quartzites.
- Geohydrological investigation has been done in the area covering Manaun, Kotuli and Katarmal. Total 57

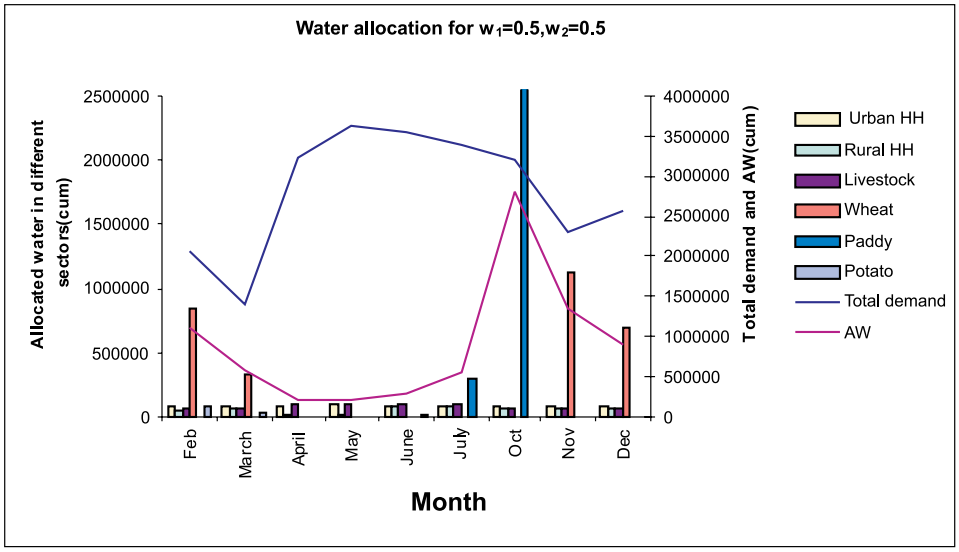



**Fig.1.** Water allocation for different sectors in Kosi watershed

springs are marked in the whole Kosi Watershed based on the toposheet. On the basis of lithology, geological structures, shear zones presence, classification of 35 springs have been done.10 Colluvial Springs, 12 Fracture/Joint related springs, 5 Contact spring, 5 Fracture/Joint/Colluvial related springs, 3 Fracture/ Colluvial related spring have been classified in the area.

- Mass curves analysis for available water with total domestic demand (rural & urban) indicates that cumulative available water is more than demand on annual scale. But, on monthly basis there is need for storage of ~ 24.3 HaM water in April and May.

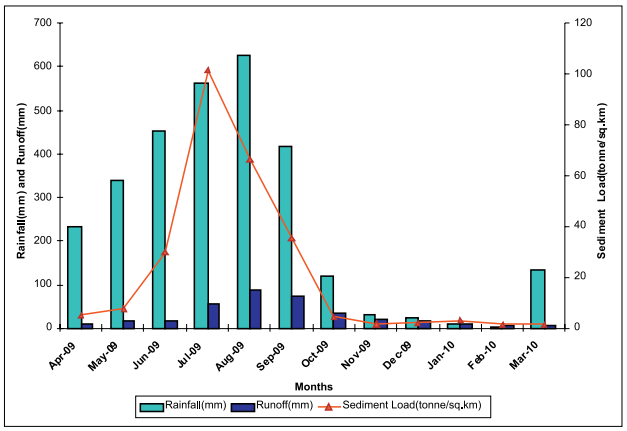



**Fig.2.** Relationship between Rainfall- Runoff and Sediment load at Balakhola sub – watershed of Taktsom Chu for the year 2009-2010

- Water allocation has been done in four major demand sectors of Kosi watershed using optimization model with equal weightage to all sectors. In each month, 5 per cent of available water is allocated in urban HH and rest available water is allocated in other sectors by applying weighting technique. During the time of water scarcity i.e. in April, May and June, water requirement of only three sectors, urban HH, rural HH and livestock can be fulfilled (Fig. 1).
- Hydrometeorology and estimation of sediment load of the Taktsom Chu watershed is carried out in detail (Fig. 2).
- Total rainfall and runoff recorded during April 2009 to March 2010 is 2954.7 mm and 350.44 mm, respectively. Runoff is 11.86% of total rainfall. Runoff and sediment are positively correlated.

## Developing sacred landscape model for eco-restoration and biodiversity conservation in the Central Himalayan Region *(2007-2012, In-house)*

Continued degradation of land and biological diversity in the Indian Himalayan region (IHR) is of serious concern in-spite of a number of R&D interventions. One of the basic reasons for ineffectiveness of the interventions adopted for degraded land rehabilitation and biodiversity conservation could be non-integration of sacred/cultural values in their approach and strategy. Keeping the above in mind, the Institute (GBPIHED) executed 'Badrivan Restoration Programme' at Badrinath between September 1993 and November 2001 and successfully revived a portion of Badrivan (*the ancient sacred forest of Badrinath shrine*), which is recognised as an inspiring model for rehabilitation of degraded lands and conservation of biodiversity based on the use of sacred/cultural values. As a follow-up of this programme, the Institute executed 'Sacred Forest Programme' at Kolidhaik (Lohaghat) between August 2004 and May 2007 and successfully established a sacred forest of various multipurpose trees with peoples' participation. Both the above-mentioned models clearly demonstrated the value of adopting 'cultural approach' for reforesting degraded lands and biodiversity conservation, and also illustrated the importance of blending science and religion for the protection of environment.

## Objectives

- To create environmental awareness among the local people for eco-restoration and biodiversity conservation.
- To develop a sacred landscape model (consisting of a sacred forest – to value peoples' sentiments, and multipurpose tree model & horticultural tree model – to meet peoples' requirements) for eco-restoration and biodiversity conservation integrating scientific and sacred values.
- To screen/identify/recommend promising plants for rehabilitation of degraded lands based on their eco-physiological health and adaptability potential.
- To make policy recommendations for the development, management and protection of sacred forests/ landscapes in the Indian Himalayan region.

## Achievements

- About 2500 pits were dug at 3 project sites [1600 at Sacred Forest Model (SFM), 800 at Multipurpose Tree Model (MTM) and 100 at Horticulture Tree Model (HTM)] in Kolidhaik village of Champawat district of Uttarakhand. The barbed wire fencing of the project area was strengthened by bio-fencing (through thorny bushes) for the protection of plants from goats, etc.
- Six contour lines (297 ft. X 1.5 ft. X 1 ft.) were dug at the SFM site with the help of 'A frame' for plantation of *Napier* hybrid grass (Fig. 3). Besides, 40 new trenches (6ft. X 1.5ft. X 2ft.) were also constructed at the site for raising water content in the soil.
- Almost 5000 seedlings of 5 promising tree species were raised in the plat nursery (in 0.5 ha) at the headquarters of the Institute.
- Almost 1600 well-established saplings of various tree species namely, Utis (*Alnus nepalensis*), Banj (*Quercus leucotrichophora*), Phalyant (*Quercus gluca*), Bhimal (*Grewia optiva*), Deodar (*Cedrus deodara*), Bitan (*Melia azedarachta*) and Bedu (*Ficus palmata*) were planted at the SFM project site by the involvement of local stakeholders. Besides, 5 quintal root stock/ cuttings of *Napier* hybrid grass was also planted in the 6 contour lines at the site.
- About 900 well-established saplings of three tree species namely, Banj (*Quercus leucotrichophora*), Phalyant (*Quercus gluca*) and Utis (*Alnus nepalensis*) were planted at the MTM project site.
- The farmers/women of 88 families of 6 villages collected 4 tonne dry fodder and 20.07 tonne green fodder (including of *Naphier* hybrid grass) from the project area.
- Almost 1100 plant saplings of three promising fodder tree species namely, Banj (*Quercus leucotrichophora*), Phalyant (*Quercus gluca*) and Bhimal (*Grevia optiva*) were distributed, free of cost, among the local villagers for plantation in and around their habitation.
- At the multipurpose tree model (MTM) site, the average survival of plants was recorded 88%; *Dalbergia sissoo* showed maximum survival (95%) whereas *Toona ciliata* showed minimum survival (53%). At the sacred forest model (SFM) site, the average survival of plants was 89%; *Alnus nepalensis* exhibited maximum survival (97%) whereas *Sapium*

**Fig.3.** Development of contour lines at the Sacred Forest Model (SFM) project site in Kolidhaik village (Lohaghat, Uttarakhand)

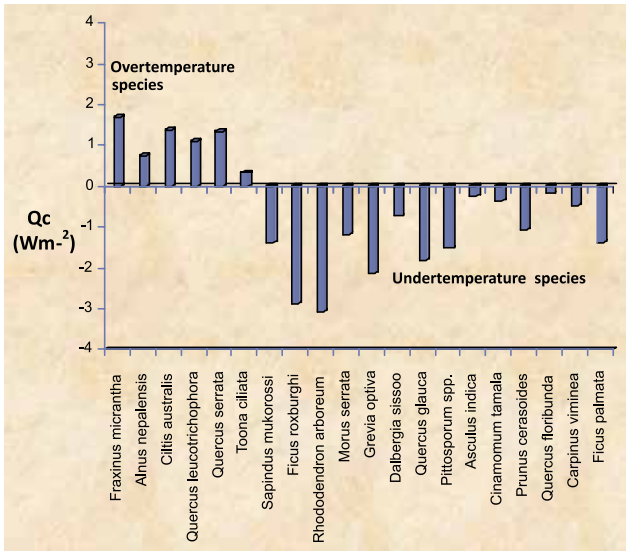



**Fig.4.** Energy loss/gain by the convection of heat (Qc) by the leaves of 20 promising tree species planted at the Multipurpose Tree Model (MTM) site at Kolidhaik village in Lohaghat.

*sebiferum* exhibited minimum survival (68%). At the horticultural tree model (HTM) site, the average survival of plants was 90%; *Citrus reticulata* showed maximum survival (93%) and *Carya illinoinensis* showed minimum survival (55%).

- The data obtained on energy loss/gain by the convection of heat from the leaves of 20 promising tree species revealed that 6 '*overtemperature*' species (namely, *Fraxinus micrantha, Alnus nepalensis, Celtis australis, Quercus leucotrichophora, Quercus serrata and Toona ciliata*) lost sufficient amount of energy by the convection of heat whereas leaves of rest of the 14 '*undertemperature*' species gained sufficient amount of energy by the convection of heat (Fig. 4).

## Installation and Operation of the Permanent GPS Stations for the Quantification of Tectonic Deformation and Assessment of Stability of Himalayan Urban Centers *(2005-2010, MoES, Govt. of India, New Delhi)*

The proposed experiment will quantify the strain suffered by the region from NW to NE along the Himalayan arc using continuously operating GPS receivers installed in permanent mode. The proposed experiment envisaged establishment of a network of GPS sites in selected urban centers to quantify the slip rate along reported faults. The selections of these sites is dictated by the disposition of anticipated active faults and the intimate knowledge of the terrain gained by extensive field work in the area. These sites fulfill the two important requirements of GPS positioning i.e. hard rock availability and sky view unobstructed by hill slopes. Repeated measurement of above mentioned sites provide information on rate of strain accumulation in the Himalaya and of co-seismic strain distribution following moderate and large earthquakes. Permanent GPS stations will be the reference station for the future campaigns for the study of Himalayan deformation rate and will fill the gap in National network of permanent stations in unrepresented areas. Daily processing of the data is being done using GAMIT/GLOBK software for baseline changes along E-W and N-S transects.

### Objectives

- Quantification of tectonic deformation field by experimentally determining the displacements of fixed sites using GPS Geodesy with high resolution.
- To measure slip rates across reported faults in the area towards improving assessmemt of the stability of different parts of the mountain urban centers.

### Achievements

- A preliminary field observation shows that the areas around all the five stations are tectonically active. Series of landslides and neo-tectonic indicators suggested that the terrain is unstable and accumulating continuous strain.
- Sixth permanent GPS station at Ziro (Arunachal Pradesh) was made functional during the year.
- Velocities of GPS stations for 2008-2009 were recorded as GBPK~ 48mm/year, GBNL ~ 49mm/year, GBSN ~48mm/year, GBKL ~ 42mm/year and GBSK ~ 49mm/year (Table-1).

**Table-1:** Velocity of permanent and IGS stations for year 2007-2009.

| Station Name | 2009-2008 | | 2008-2007 | | 2008-2007 (http://itrf.ensg.ign.fr) | |
|---|---|---|---|---|---|---|
| | Velocity (mm/y) | Error (mm/y) | Velocity (mm/y) | Error (mm/y) | Velocity (mm/y) | Error (mm/y) |
| KUNM | 38.12 | 0.63 | 38.95 | 0.62 | 35.11 | 0.61 |
| LHAZ | 55.37 | 0.59 | 50.51 | 0.59 | 48.08 | 0.24 |
| HYDE | 53.21 | 0.77 | 46.93 | 0.84 | 53.95 | 1.93 |
| IISC | 53.02 | 0.64 | 53.1 | 0.65 | 52.96 | 1.24 |
| SELE | 29.26 | 0.45 | 28.8 | 0.43 | 28.26 | 0.30 |
| POL2 | 28.50 | 0.45 | 27.72 | 0.43 | 27.92 | 1.36 |
| KIT3 | 28.64 | 0.52 | 28.14 | 0.50 | 28.30 | 1.00 |
| GBPK | 47.94 | 0.62 | 50.03 | 0.58 | - | - |
| GBSK | 49.34 | 0.62 | 49.15 | 0.61 | - | - |
| GBNL | 49.89 | 0.60 | - | - | - | - |
| GBSN | 48.58 | 0.64 | - | - | - | - |
| GBKL | 41.57 | 0.61 | - | - | - | - |

**KUNM: Kunming, LHAZ: Lhasa, HYDE: Hyderabad, IISC: IISC Banglore, SELE: Selezaschita, POL2: Poligan, KIT3: Kitab, GBPK: Katarmal GPS station, GBSK: Sikkim GPS station, GBNL: Nainital GPS station, GBSN: Srinagar GPS station, GBKL: Kullu GPS station**

## Stabilization of Landslide through engineering and bio-engineering measures in Sikkim *(2007-2012, In-house)*

About 70% of the road network in Sikkim lies in hill and mountainous terrain with steep slopes and fragile rocks that are prone to landslide, especially during rainy season. Various types of landslides such as debris flow, rotational and rock slide etc. occurs frequently along these roads and its vicinity. In the recent years large numbers of landslides have caused extensive damages to the roads, buildings, forests and agricultural fields in many parts of the state. Many of them are caused by excessive road cutting. These hazards cannot be prevented in all cases but the impacts can be minimized to a certain extent by taking effective timely measures to cope up with them for disaster preparedness. Bio-engineering should be a fundamental part of the design and construction of all roads in hill areas to prevent landslides caused by road cutting. This is mainly because it provides the best way to armour slopes against erosion, and can also provide a significant contribution to soil reinforcement and other anti-failure measures. These measures are relatively low in cost, use of local materials and skills provide livelihood benefits to the locals. The vegetative structures are also flexible, being capable of absorbing movement and recovering from damage. On roadsides, plants reduce the supply of debris from degrading slopes, which is one of the greatest contributors to road maintenance costs through blocked drains and damaged pavements.

### Objectives

- Development of landslide inventory of Sikkim.
- Undertake Global Positioning System (GPS) survey of Bakthang fall subsidence/slide.
- Stabilization of landslide through engineering and bioengineering measures in Sikkim.
- Provided technical know that how about stabilization measures to Forest Department (GoS).

### Achievements

- Generated landslide inventory of North District (Fig.5).
- Updated landslide map of Sikkim using recent field visits (229 landslide locations) and RS data of 2006 (121 landslide locations).
- Landslide stabilizations using engineering and bioengineering measures in the Bojeck landslide has been initiated (Fig.6 a, b).
- Periodical Global Positioning System (GPS) monitoring (eight campaigns) of Bakthang fall subsidence/slide for its movements.
- Plant nursery of soil binding species has been raised in the Unit.

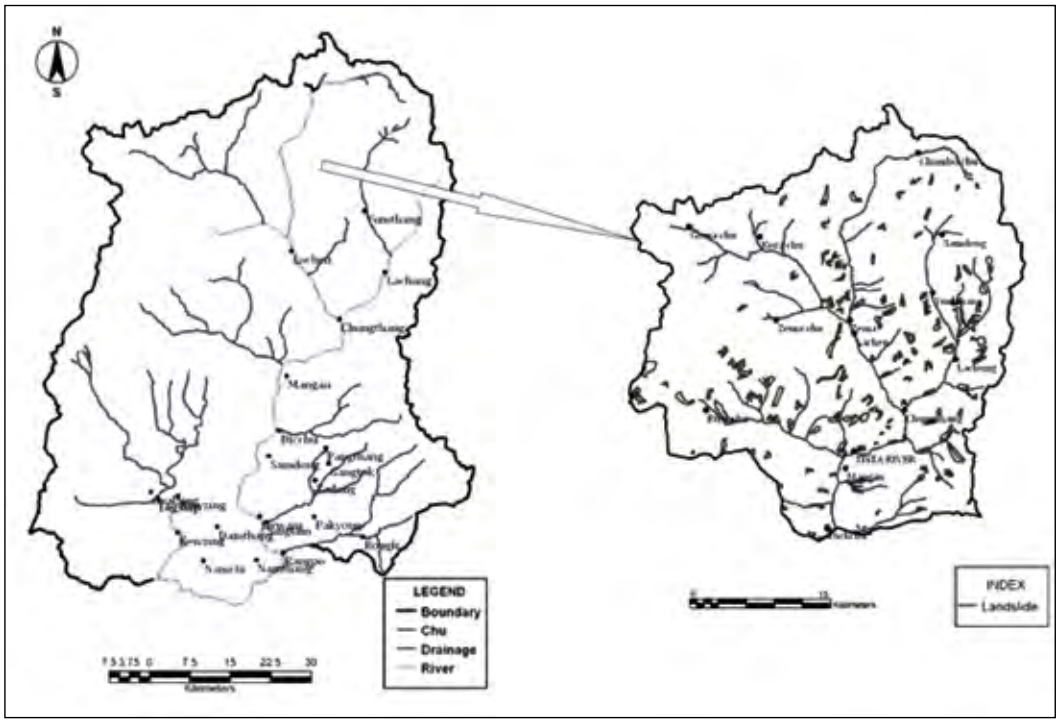



**Fig.5.** Landslide inventory map of North Sikkim

**Fig.6. (a)** Engineering measures (catch water drains) in Bojeck landslide

**Fig.6. (b)** Winter plantation in Bojeck slide

### Disaster Management Faculty-Sikkim *(2003-2012, National Institute of Disaster Management (NIDM), Ministry of Home Affairs Govt. of India, New Delhi)*

The Faculty on Disaster Management aims to contribute to the priority action programs in the areas of natural disaster management through capacity building of the management systems at different levels. The mandate of the faculty is training/education and awareness generation through appropriate trainings of various target groups in consultation with the Land Revenue Department, Govt. of Sikkim so as to strengthen the State level and District Level disaster management systems including NGOs, CBOs, Panchayats, and Local Community level systems. Faculty organizes various programmes to all levels of stakeholders in the state independently as well as with National Institute of Disaster Management, Govt. of India New Delhi and Land Revenue and Disaster Management Department, Govt. of Sikkim.

### Objectives

- The Disaster Management faculty acts as a focal point for the State on following specific areas/activities related to management of natural disasters:

1. Training and Awareness generation
2. Research studies
3. Documentation
4. Development of data base

### Achievements

- Close interaction with Land Revenue and Disaster Management Department, Govt. of Sikkim has been established to execute the D.M. Faculty programmes on disaster management for various level of stake holders in the state. Various programmes *i.e.* training, training cum workshop, popular lectures, etc. organized by faculty in the state. During training programme requirement for reading material, brochures, training module, pamphlets developed in English/Hindi/Nepali) related to the subject distributed among the participants.

1. Organized training programmes to various level of stake holders in the state. Total 13 training programmes have been organized in the state covering 832 numbers of participants.
2. Documentation/data has been collected from various related departments to update the existing information.
3. Survey of various disaster triggered in the state is initiated.

### Energy use pattern in rural domestic sector of Uttarakhand State – Issues, Options & Challenges *(2007-2012, In-house)*

Use of energy is essential key in the functioning of human society. Nature and availability of energy determine pace of development and magnitude of many global processes (changes in forest cover and habitat alteration, land production and degradation, climate change, and politics of fossil fuel). More than half of the world's population lives in rural areas, nearly 90% of them in the developing countries, dependent on the traditional fuels often using primitive and inefficient technologies. Rural domestic energy requirements are mainly for cooking, lightning, and space heating. Thus, in addition to affluence as a variable, geography also play crucial role in energy use and associated processes. Increasing demands of the growing rural population has put additional pressure on the local resources. Wide variety of energy resources and their highly site-specific and variable nature, coupled with different types and qualities of energy needs, pose a challenging problem in the designing of an integrated planning and management system. This study will build synergy between the local options and governmental

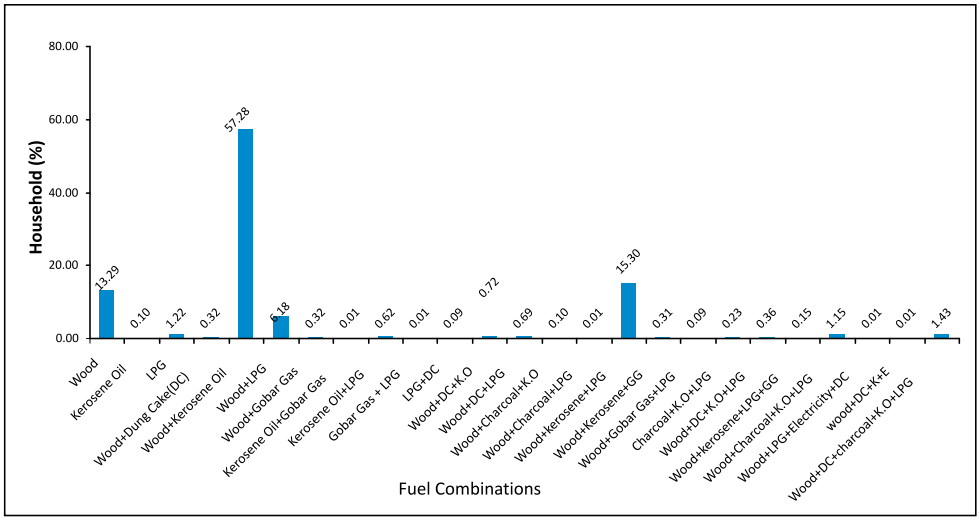



**Fig.7.** Energy mix scenario of households for cooking energy.

efforts, and is expected to highlight socio-economic and environmental benefits of various energy options. Providing mechanism for integration of rural energy requirement and convergence of incentives with other development factors for better implementation of energy management is expected.

## Objectives

- To analyze patterns of domestic energy requirements with varying variables in rural settings for projection of future patterns and impact on resources.
- To understand technical, institutional and financial mechanisms in rural energy demand, supply, and alternatives for planning and management.

## Achievements

- Among all the Himalayan states, Uttarakhand state shows highest use of solar energy for domestic lighting purposes (2% of the total households), while in the year 2007-08 solar lighting in 2780 households were provided.
- A very small fraction of households (< 4800 households) does not have access to any lighting energy. In the rural scenario Garhwal Division of the Uttarakhand state had more progress in rural electrification as apparent from higher number of households having electricity for lighting (~51%) than in the Kumaun division (49.6%), lesser share of households using kerosene oil (45.6% *vs* 48.0%), and without any lighting (0.2% *vs* 0.3%).
- Nearly one fourth of the total electricity consumption in the State is for domestic purpose. However, the domestic consumption has increased in the recent years (13% since 2005). Share of this sector to the total electricity consumption in the state is decreasing (30% in year 2005) which is due to growing demand in industrial sector while total electricity generation remains almost same in this period.
- 3,300 households were surveyed in different districts of the state to add a total of 13,300 samples. Various kitchen fuels are firewood, kerosene oil, LPG, dung cake, charcoal, *gobar* gas, and electricity. 25 combinations of these different kitchen fuels are used to meet cooking demands. Still 13% households are exclusively dependent on firewood for cooking needs; however other households use firewood in combination of other kitchen fuels. Among them most prevailing was use of two types of energy (57.3%% of the total households use wood and kerosene oil), and 15.3% use three cooking fuels (wood, kerosene oil and LPG, Fig. 7). Use of primitive type of energy (fuel wood) is most common practice. Exclusive use of LPG for cooking is also visible but at a smaller scale. This shows transformation process is active but pace is slow.

## Exploration, diversity, and mapping of vegetation in the urban forests of Kumaun Himalayan towns using Remote Sensing & GIS *(2008-2011, Ministry of Environment & Forests, Govt. of India, New Delhi)*

It is expected that in the 21st century urban population will share majority of the world's population. Urban centres (Cities and towns) can be defined as ecosystems to explain ecological and social systems and the interaction of these two. Natural vegetation in an urban ecosystem is subject to modification, rearrangement, and conscious or accidental design by humans. Trees and vegetation contribute to the beauty, distinctiveness, and material

value of communities by incorporating the natural environment into the built environment. Information from high-resolution satellite remote sensing can be integrated with a city's vegetation information for a complete inventory and detailed mapping of the urban environment to define boundaries of different components and their role in functioning. This has been observed that land uses take on different functions depending on their location in the urban matrix. Human activities, such as informal management, play a key role in the provision of critical ecosystem services, something that largely is unperceived in official green area management strategies.

## Objectives

- To explore diversity and structure of urban forest/ vegetation for identification of processes and factors to determine different vegetation types, and to identify positive and negative forces in maintaining the diversity in the towns.
- To map urban forest/vegetation in the urban areas; analyze landscape attributes (e.g., patch and matrix) using high resolution satellite data and record changes in the urban green areas in the Kumaun Himalayan region along temporal scale.
- To suggest measures for conservation of biodiversity in urban areas for formulation of policies for management of urban green areas.

## Achievements

- Landuse/Landcover map of Almora town using LISS-IV satellite image was prepared which consists of twelve different classes. Mapable urban vegetation in the town area are - Pine, Cedar, Coniferous, Broad leaf evergreen, Broad leaf deciduous, Broad leaf evergreen mix deciduous, and Broad leaf mix coniferous (Fig. 8). The non-tree areas include open areas without tree, shrub/scrub, and agricultural land, built up area and play ground. The total land use by the tree cover was 194.85 ha that is 53.5 % of the total area of town.

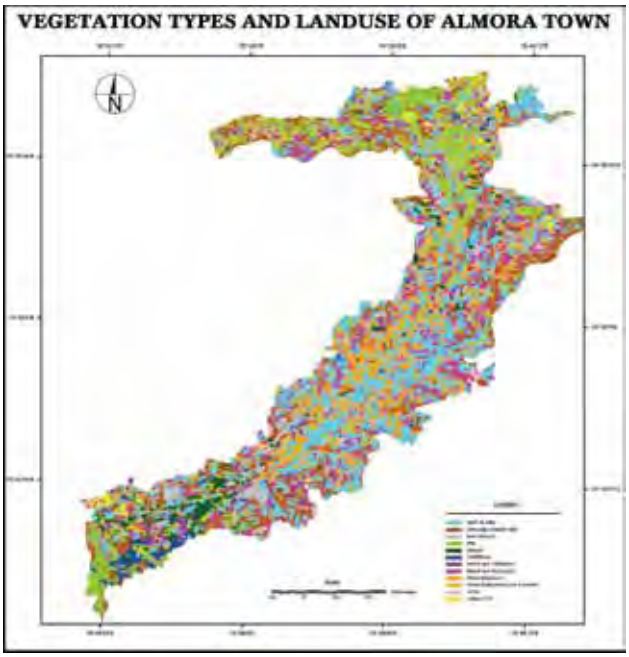



**Fig.8.** Landuse/landcover map of Almora town.

- Broadleaf deciduous cover an area of 55.52 ha which is 15.1% of the total tree cover. It occupies the maximum area of the total tree cover. Broad leaf evergreen forest occupies least area i.e. of 1.96 ha which is 0.5% of the total tree cover. Among the non-tree areas Built up area had the largest share of 105.35 ha that is 28.9% of the Non-tree area. The smallest share is of agricultural land which constitutes 3.56 ha of the total Non-Tree area. It is only 1% of the land use of the Non-tree area. (Table 2).

**Table-2:** Landuse statistics of Almora Town

| No. | Landuse / Landcover | Area (ha) | (%) |
|---|---|---|---|
| 1 | Pine | 25.63 | 7.1 |
| 2 | Cedar | 12.28 | 3.4 |
| 3 | Coniferous | 6.74 | 1.9 |
| 4 | Broadleaf evergreen | 1.96 | 0.5 |
| 5 | Broadleaf deciduous | 55.52 | 15.1 |
| 6 | Broadleaf evergreen mix deciduous | 42.70 | 11.6 |
| 7 | Broadleaf mix coniferous | 50.03 | 13.6 |
| 8 | Open area without trees | 48.18 | 13.4 |
| 9 | Shrub/Scrub | 6.03 | 1.7 |
| 10 | Agricultural land | 3.56 | 1 |
| 11 | Built-up area | 105.35 | 28.9 |
| 12 | Playground | 6.56 | 1.8 |

- Among 12 different wards the area under tree cover ranges from 35.8% to 61.9% of the total area of that ward. Two wards have tree coverage more than 60% of the total ward area, while 6 wards have area more than 50% of the total area under tree cover.

## Nematode diversity in the traditional agro ecosystem of central Himalaya, their impact on soil health, crop growth and development of demonstration model for agro-ecotourism *(2007-2012, In-house)*

Nematodes are important mineralizes in systems poor in nitrogen; approximately 40% of total mineralization in certain ecosystem is due to grazing of microbial populations by nematodes and other soil fauna. Information on soil nematode diversity and their role in the traditional cropping system is fragmentary. Developing an understanding of fluctuations in nematode diversity and nitrogen mineralization is desirable for exploiting the supply of nutrients that might become available for crop use.

### Objectives

- To examine the nematode diversity in the traditional agro ecosystem across the year under different cropping combination.
- To analyse the relationship of the nematodes with soil health (nitrogen dynamics) under different cropping combination.

### Achievements

- One way ANOVA and correlation coefficient values indicated significant differences in rate of N-mineralization due to bacterivore and fungivore nematodes which play an important role in decomposition cycle.
- The nematode channel ratio (NCR) of (0.79) was highest for plots planted with wheat and mustard in equal ratio indicating efficient and faster bacteria mediated channel for decomposition while lowest NCR (0.63) was recorded for wheat sole cropping indicating a slower fungal channel decomposition cycle. Mustard sole cropping had an NCR of 0.77, which means mustard promotes faster bacterial decomposition and cultivating the crop with wheat is a healthy practice.
- Nematodes identified from *rabi* cropping (winter cropping) season belonged to two class, Secernentea and Adenophora. Under Secernentea three orders were identified. 1. Rhabditida 2. Tylenchida and 3. Aphelenchida. For class Adenophora two orders were identified Dorylaimida and Mononchida. The genera identified were classified into trophic groups and are presented in Table-3.

## Indigenous Knowledge: Traditional Health Care Practices in Rural Areas of Uttarakhand – Central Himalaya *(2007-2012, In-house)*

In India, traditional health care practices, particularly use of medicinal herbs for healing, is a practice since time immemorial. Such practices are still continuing in rural area as they are inexpensive, culturally familiar and readily available. However, due to excessive removal of herbs from wild for commercial use and rapid forest degradation in recent past, the number and quantity of herb species has declined in the wild. In Uttarakhand, majority of traditional health care practiceners (THCP), locally called *vaidyas*, are found in remote rural areas and have great utilities to the community in absence of modern health services. The *vaidyas* use largely medicinal herbs for preparation of formulations and treatments. Documentation of herbal formulations, its compositions and preparatory methods shall be useful for protecting the indigenous knowledge of the *vaidya* system.

**Table-3:** Genera of nematodes identified and classified into trophic groups from soil planted to wheat-mustard.

| Bacterivores | Fungivores | Herbivores | Omnivores | Predators |
|---|---|---|---|---|
| *Mesorhabditis* | *Tylencholaimus* | *Psilenchus* | *Prodorylaimus* | *Mononchus* |
| *Caenorhabditis* | *Dorylaimoides* | *Tylenchorhynchus* | *Mesodorylaimus* | *Clarkus* |
| *Cephalobus* | *Promumtazium* | *Helicotylenchus* | *Thornenema* | *Prionchulus* |
| *Eucephalobus* | *Aphelenchus* | *Hemicriconemoides* | *Baqriella* | *Coomansus* |
| *Acrobeles* | | *Ogma* | *Opisthodorylaimus* | *Mylonchulus* |
| *Acrobeloids* | | *Criconemella* | *Morasia* | *Paramylonchulus* |
| *Chiloplacus* | | *Xiphinema* | *Eudorylaimus* | *Itonchus* |
| *Zeldia* | | *Trichodorus* | | *Abunema* |
| *Pseudacrobelus* | | *Paratrichodorus* | | *Discolaimus* |
| *Plectus* | | | | *Ironus* |
| *Chiloplectus* | | | | *Tripyla* |
| *Prismatolaimus* | | | | *Coomansinema* |
| *Alainus* | | | | *Aporcelaimellus* |
| *Amphidelus* | | | | *labronema* |

## Objectives

- Documentation of traditional health care practices.
- Documentation of plant species used in traditional health care practices.
- Documentation of IK of practices, processes, knowledge and resources use in traditional health care practice.
- Status of herbs used by the traditional herbal healers in the wild.
- Identification of possible IPR value.

## Achivements

- In the 10 studied villages, total 29 *vaidyas* were extensively interviewed for various aspects of the traditional therapies, out of them 75.9% *vaidyas* were male and 24.1% were woman *vaidyas.* In the family girl child is not preferred for this profession with a fear that after the marriage this family knowledge would pass to other family.
- Among 29 studied *vaidyas,* about 48.3% of the *vaidyas* did self herbs collection from wild; 20.7% took help of alpine graziers for procurement of high value herbs from alpine meadows, 27.6% used both methods of self herb collection and through graziers and only 3.5% *vaidyas* used standard herbal preparations (powder, mixtures and pills, etc.) of standard ayurvedic firms. Beside these some of the *vaidyas* had their own herbal garden in the premises of their home containing more than two dozen herbs.
- Traditional *vaidyas* and villagers of the studied villages used about 155 plants (90 plants identified for their Latin name and 65 with vernacular names). Identified plants were of 64 families (Table-4). Highest number of species were from family Lamiaceae (6 species), followed by Apiaceae (5 species), Ranunculaceae, Euphorbiaceae & Liliaceae (4 species from each family), Solanaceae, Moraceae & Asteraceae (3 species from each family). Families such as Acanthaceae, Combritaceae, Rutaceae, Boraginaceae, Cucurbitaceae, Aspergaceae, Apocynaceae, Zingiberaceae, Orchidaceae and Poaceae contributed 2 species from each. 35 herbs were single representatives their respective families.
- Ninty three herbal formulations used by the traditional *vaidyas* were documented with their, composition, plant part used, use method and villages of their use. Out of them 83 formulation were used for treatment of human ailments and 10 were used for treatment of cattle. In 2 formulations animal product and in 2 formulations mineral/chemical were also used. 15 formulations of *Tinospora cordifolia* (*Giloe*) have been witnessed, out of these 6 are already in literature and 9 are new.

**Table-4:** Medicinal plants used by vaidyas & villagers in Upper Alaknanda valley in Urttarakhand

| S.N. | Family | Number of species used | Species |
|---|---|---|---|
| 1. | Lamiaceae | 6 | *Colebrookea oppositifolia, Ocimum americanum, O. sanctum, Origanum vulgare, Ajuga parviflora, Mentha arvensis* |
| 2. | Apiaceae | 5 | *Centila asiatica , Foeniculum vulgare, Selinum candollii, Pleurospermum angelicoides , Angelica glauca* |
| 3. | Ranunculaceae | 4 | *Aconitum heterophylum, Thalictrum foliolosum , Delphinium cashmerianum, Aconitum atrox* |
| 4. | Euphorbiaceae | 4 | *Ricinus communis, Emblica officinalis, Septum insigne, Mallotus philippensis* |
| 5. | Liliaceae | 4 | *Fritillaria cirrhosa, Allium humile, Fritillaria roylei, Chlorophytum arundinaceum* |
| 6. | Solanaceae | 3 | *Withania somnifera , Solanum nigrum, Solanum indium* |
| 7. | Moraceae | 3 | *Ficus palmate, Ficus racemosa, Ficus religiosa* |
| 8. | Fabaceae | 3 | *Butea monosperma, Abrus precatorious , Astragalus sp.* |
| 9. | Asteraceae | 3 | *Anaphalis adnata , Matricaria camomillia, Saussurea costus* |
| 10. | Acanthaceae | 2 | *Adhatoda vasica nees , Barleria prionitis* |
| 11. | Combretaceae | 2 | *Terminalia bellirica, Terminalia chebula* |
| 12. | Rutaceae | 2 | *Citrus medica, Zanthoxylum armatum* |
| 13. | Boraginaceae | 2 | *Arnebia benthamii, Arnebia benthamii* |
| 14. | Cucurbitaceae | 2 | *Citullus colocynthis , Diplocyclos palmatus* |
| 15. | Apocynaceae | 2 | *Cerium indium , Rauwolfia serpentina* |
| 16. | Zingiberaceae | 2 | *Roscoea procera, Hedychium spicatum* |
| 17. | Orchidaceae | 2 | *Dactylorrhiza hatagirea, Satyrium nepalense* |
| 18. | Poaceae | 2 | *Cynodon dactylon, Triticum aestivum* |
| 19. | 36 Families, each contributing one species | 36 | 36 medicinal plant species each form different family. |

## Development of Analytical Models through Establishment of Modeling & Statistical Computing Laboratory: An attempt towards Capacity Building

*(2009-2014, In-house)*

The proliferation of digital technologies and pervasive networks through which data are collected, generated and shared requires comprehensive infrastructure that can be used to capitalize on remarkable advances in IT and thus integrates hardware for data organization, computation, analysis and modeling. Establishment of modeling and computing laboratory represents the core of this research group and is a part of R&D works and capacity building activities of the Institute. GBPIHED, through its R&D activities, has produced large volume data on different aspects which is scattered and thus needs to be organized and integrated with other research activities. Keeping in view of the interdisciplinary research work in the Institute, a network based resource centre for modeling and for capacity building is required, which can efficiently be used to access, organize, integrate, and statistically analyze the large datasets on different aspects to provide appropriate mathematical treatment to different research problems. These issues has been raised in the previously held SAC meetings of GBPIHED and in the National brainstorming meeting organized by the Institute on September, 8th, 2007 and then it was recommended to develop a comprehensive and validated data base on different aspects and their qualitative assessment and analysis using statistical and modeling techniques.

### Objectives

- To develop long term database for available data on different aspects, gap analysis and apply various statistical and mathematical tools for analysis and development of analytical model.
- To strengthen the modeling and statistical computing facility with particular emphasis on computer aided mathematical modeling and its application into various interdisciplinary research activities.
- To train fellow researchers on different available softwares/ packages by providing regular hands-on-training.

### Achievements

- Compilation of meteorological data of past 107 years (1901-2008, excluding 2003) for all districts of the twelve states in Indian Himalayan region (IHR) has been done. The parameters include; monthly & total annual rainfall, maximum, minimum & average temperature, Diurnal temperature range, Potential evapotranspiration, Cloud cover, Vapour pressure, Wet day frequency and Ground frost frequency. Data are obtained through Climate Research Unit (CRU), UK & India Meteorological Department (IMD).
- Regular collection & management of the real time meteorological data from the weather profiler installed at GBPIHED Almora is being done. The parameters include; daily & 30 minute average rainfall, temperature, relative humidity, wind velocity, wind direction, soil moisture, soil temperature, net solar radiation and atmospheric pressure.
- A record of the climatic variables (Precipitation & Temperature), obtained from IITM, Pune through PRECIS output run, for two scenarios (1961-90 & 2071-2100) has been compiled for the Upper Bhagirathi catchment.
- Compilation of Software (HEC-HMS and STATISTICA) for development of resource base for modeling & data analysis. The softwares are being utilized by fellow researchers of the Institute for data analysis in various research activities.
- Organized a hands-on-training programme for the research scholars of the Institute on STATISTICA and developed its training manual; 14 research students were trained for using STATISTICA software for their data analysis.

## Recharge area identification and estimation mean residence time for springs in one urban and one rural microwatershed in Pauri Garhwal using isotope technique, remote sensing, and GIS for implementation of artificial recharge structures

*(2009-2014, GBPIHED and NIH, Roorkee)*

Water Resource is becoming the biggest concern in Indian Himalayan Region especially during the summer. This project is an attempt to quantify the available water resource in two micro-watersheds, one urban micro-watershed (Pauri Urban Area) and the other is rural micro-watershed (Dugar-gad watershed). Through this project an attempt will be made to find out the probable recharge area of springs falling in the study area using the state-of-art technology and implement the ground water recharge structures to augment the spring discharge.

### Objectives

- To decipher the recharge zone and mean residence time for springs falling in the study area using isotope technique.
- To analyses the relationship of rainfall, evaporation, hydrogeology, landuse / landcover, ecological factors with the spring discharge.
- To implement rainwater recharge structure in the catchment area and execute water harvesting structures to enhance the productivity of the fracture hard rock aquifer.

## Achievements

- Installation of equipments in the two micro-watersheds is complete for daily measurement of the discharge data of springs and streams as well as evaporation.
- Collaboration with National Institute of Hydrology, Ministry of Water Resource, Roorkee is finalized for isotope analysis of rainfall and spring discharge data for subsequent two years.
- Rain gauge installation in six locations in both the study area for rainfall sampling is also under completion.

## Development of ecosystem integrity profile using ecometric methods for ecological risk assessment in mountains *(2008-2011, DST, New Delhi)*

The Himalayan mountain region features a great diversity of climate, topography, hydrology and ecology as well as diversity of communities and culture. Therefore sustainable development of mountain ecosystems demands integration of research and development programs having strong emphasis on ecosystem components with social, cultural and ecological consideration. The project aims to develop approaches which provide authentic and precise details of the state of health of mountain ecosystems. The main focus is on the development of ecosystem integrity profiles using physical, biological and social attributes of the ecosystem in integrated manner. Development of ecometric methods using information on ecosystem at landscape level could emerge as a viable option. Particularly, the comparative analysis of outcomes of such models among different mountain systems would result in testing the efficiency of such approaches for risk and susceptibility assessment in targeted mountain ecosystem.

This project is implemented in the three catchments namely, Gaula catchment - low altitude transect (Area: 600km$^2$; Location: 29$^0$12'-29$^0$27' N to 79$^0$'26'-79$^0$49' E), Upper Kosi catchment- mid altitude transect (Area: 480.15km$^2$; Location: 29$^0$30'-29$^0$55' N to 79$^0$'30'-79$^0$45' E), and Pindar catchment- high altitude transect (Area: 557.63km$^2$; Location: 30$^0$03'-30$^0$19' N to 79$^0$'45'-80$^0$05' E). These sites together represent entire elevation gradient of the region and therefore the diversity of ecosystems.

## Objectives

- Study of ecosystem integrity (*i.e.* health, resilience, diversity, stability and sustainability) through evaluation of critical ecosystem elements and processes.
- Development of ecosystem integrity profile (reckoner) and indices (based on 1 above) for carrying capacity and risk assessment using ecometric methods and models.
- Approaches and strategies for ecological risk management and delineating critical ecosystem components

## Achievements

- The present land use data of Gaula catchment was compared with the land use for the years 1962-63, 1973, and 1985-86. The comparison of land use indicates significant increase in barren/scrub land during the study period (2008).
- The annual rainfall and annual runoff of Gaula catchment (period 1958-2005) was investigated using Double Mass Curve method. The double mass curve and slope of trend curve shows the runoff of Gaula catchment in the period 1968-1977 is more than the periods 1958-1967, 1978-1986 and 1986-2005 with similar rainfall (Fig. 9).

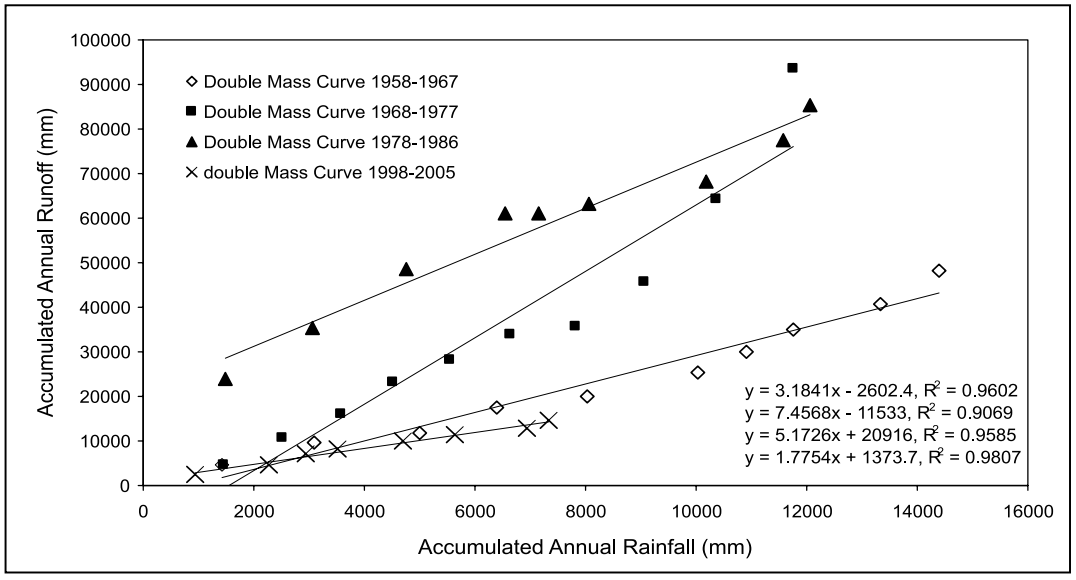



**Fig.9.** Mass Curve of rainfall-runoff for the period 1958-2005 of Gaula catchment.

- Annual runoff and sediment load data of Gaula catchment (from 1985 to 2005) was also investigated using Double Mass Curve method. The double mass curve of runoff and sediment of Gaula catchment indicates more sediment yield in the period 1996-2005 than the period 1985-1995 with similar rainfall or runoff.

## Development of Early Warning Model for landslide using Remote Sensing and GIS: Case study from Sikkim *(2008-2011, Space Application Centre, Ahmadabad)*

Landslide is the most prominent and frequently occurring environmental hazard in the hilly areas, affecting the physical and cultural landscapes. In the Sikkim Himalaya most of the landslides occurs during monsoon season. Prominent factors controlling landslides are lithology, slope, drainage, landforms, different land use and unusual behavior of rainfall pattern in the hilly terrain. Satellite remote sensing with improved spatial resolution in recent years has made it possible to map and monitor geo-environmental factors affecting landslides and to understand the underlying mechanism behind them. Many a times landside causes colossal loss to life and property. The early warning of triggering of landslide in a known area could be of immense importance. The database developed in the past on the landslides in the Sikkim Himalaya is not enough for preparing an Early Warning Model. Therefore, an attempt is being made for the development of Early Warning System for landslides using Remote Sensing and GIS tools.

### Objectives

- Attempt to establish threshold value of rainfall for landslide occurrence.
- Attempt to generate probable landslides initiation points using slope stability models in GIS.

### Achievements

- Landslide Inventory map of Sikkim has been prepared. The detailed inventory of old, new landslides had been done using the Survey of India Toposheets (SoI), remotely sensed data (IRS, 1C, 1D,) and the field survey conducted in the four districts of Sikkim (Table-5 ).
- Collection of ground controlled points (GCPs) for the geo-coding of Cartosat Stereo-1 data is done. The collected Ground Controlled Points will be used for the development of Digital Elevation Model (DEM) of the selected areas *i.e.* Gangtok, Lachen, Ravangla and Geyzing.
- Development of major lineament map using IRS, 1C, LISS-III data of 1997 on the scale of 1:50,000 have been completed.
- Geocoding and digitization of Geological map of Sikkim prepared by Geological Survey of India, on the scale of 1:50,000 is completed.

**Table-5:** Detail of landslides mapped

| State | Data / sheet used for mapping | No. of landslides mapped |
|---|---|---|
| Sikkim | SOI (1962-63) | 97 |
| | Satellite Data (1997) | 57 |
| | IRS- 1D,LISS- IV (2007) | 65 |
| | Field Survey 2008-2009 | 102 |
| | Field Survey 2009-March 2010 | 229 |

## Impacts of global change on the dynamics of snow, glaciers and runoff over the Himalayan Mountains and their consequences for highland and downstream regions *(2008-2010, Asia-Pacific Network)*

The frozen water in the Himalaya is crucial for the people inhabiting the mountain areas as well as the downstream areas. Without snowmelt, the rivers flowing down from the Himalaya would remain dry for greater part of the year, thereby seriously affecting the livelihood of people and economy of the country. This study is intended to provide science based information about the impact of global change on glaciological and hydrological systems in the Himalayan region. Therefore, the estimation of trend of snow & glacier melt under changing climatic condition and their impacts is critically important, and needs to be addressed using various snowmelt runoff models. For national case study in India, the Upper Bhagirathi river basin, located in the state of Uttarakhand has been selected. The valley's (Upper Bhagirathi) total glaciated area is about 258.56 km2 which is approximately 34% of total glaciated area of the Upper Bhagirathi catchment.

### Objectives

- Simulation & validation of climatic variables in the region by using PRECIS data.
- Simulation of runoff from snow and glacier melt & validation by field/satellite data.
- Assessment of dynamics of accumulation and depletion of snow and glacier by using field data/ satellite imagery and its validation.

### Achievements

- Rainfall during June-September has decreased by approximately 10-15 mm in the last 8 years in Upper Bhagirathi basin (Fig. 10). Decreasing trend of rainfall has also been estimated in model data (PRECIS), both annually and seasonally during the last 30 years in the region. Pre-monsoon rainfall shows 2-7% decline from the annual average.

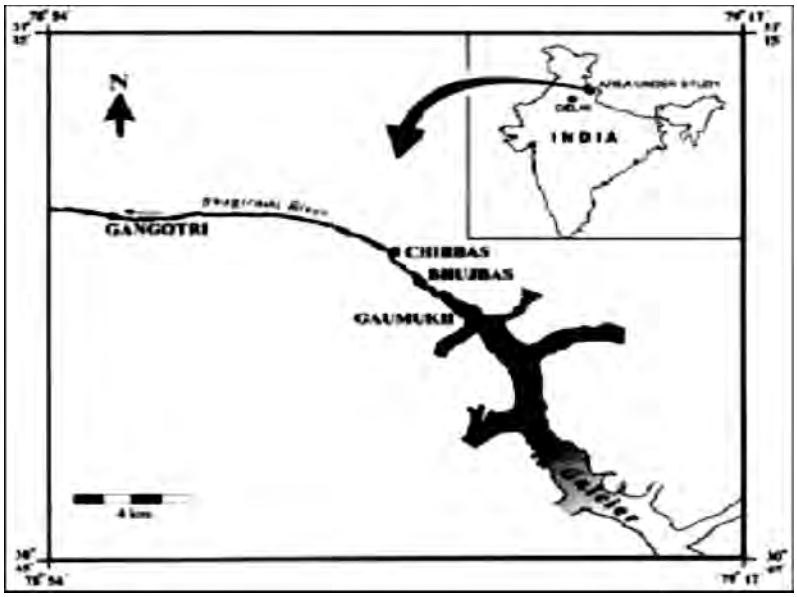



**Fig.10.** Location map of upper Bhagirathi basin

- Projections for 2071-2100 for A2 scenario (PRECIS) show a decreasing trend of rainfall, both annually and seasonally, whereas an increasing trend is indicated during the winter season. The projections show an average of 3-4 mm decline in pre-monsoon, 5-8 mm decline in monsoon period, and 6-9 mm decline in the post-monsoon rainfall, whereas 2-5 mm increase is indicated in the winter rainfall.
- A mixed trend of temperature has been recorded at the gauging site which shows increase in the mean temperature up to the year 2006, but thereafter a decreasing trend is seen for two years (2007-08).
- In the past 30 years (PRECIS data for 1961-90), pre-monsoon temperature has increased by 2-3$^0$C, whereas average temperature for the monsoon period has increased by 1-2$^0$C in the region. Similarly, an increase of 3$^0$C in the post-monsoon temperature and 3-4$^0$C in the winter temperature has been recorded in the last 30 years.
- The projections for 2071-2100 for A2 scenario (PRECIS) indicate an increasing trend of temperature, both annually and seasonally. The PRECIS output data project 2-4$^0$C increase in temperature in winters, 3-5$^0$C rise in temperature in pre-monsoon, 1-2$^0$C rise during the monsoon, and 3-4$^0$C rise in temperature in the post-monsoon periods.

## Participatory Water Management Plan for Mid Altitude Himalayan Villages using optimized water harvesting systems *(2009-2012, DST, New Delhi)*

Pressure of human population tended to increase rapidly over last 100 years. As long as water demand remains small compared to its availability, all users can coexist without conflicts and as such the problem of water allocation does not arise but with the increase in demand the conflicts between user's increases in frequency and its impact on water resources becomes noticeable. Thus, to avoid the conflicts between the competing demands and changing climate conditions, proper water allocation and water management planning is required. The present study is being carried out in the three selected villages of Upper Kosi-catchment in Almora district of Uttarakhand. These villages were selected considering the specific location, population and social structure representing all section of the village society. The whole study is based on participatory planning approach. The parameters for optimization will be derived using quantification of the resources, prioritization of demand sectors and weighting of the use of management practices followed for conservation and allocation of resources to demand sectors.

### Objectives

- Quantification of water resources and demand at village level.
- Scenario building on variable water availability and optimization model of water allocation.
- To develop and test the participatory water management plan for optimizing water distribution within a single village system.
- Development of guidelines for integrated water management plan for implementation at village level.

**Table-6:** Available water during summer in Railakot Village

| Hemlet | Total HH | Total population | Total HH Demand (l/d) | Total springs | Dry Springs | Total available water for domestic use (l/d) | Available water for Irrigation (l/d) |
|---|---|---|---|---|---|---|---|
| Padyula | 34 | 136 | 8670 | 3 | | 38698 | - |
| Railakot | 80 | 320 | 20400 | 2 | | 29360 | - |
| Syuda | 23 | 92 | 5865 | 2 | 1 | 1923 | - |
| Dobatiya | 12 | 48 | 3060 | 2 | | 750 | - |
| Dulegaon | 74 | 296 | 18870 | 4 | 1 | 28331 | 118242 |

HH: Household, LS: Livestock

## Achievements

- Three sites (Manaun, Railakot and Pachchisi) have been selected for water management study and demographic data were collected and processed.
- Household survey and data collection regarding water use pattern and peoples' perception about changing climatic condition and water availability have been done for Manaun and Railakot villages. Water consumption for household purpose was approximately 40 litres per capita per day during summer and 25 litres per capita per day during winter. Water consumption of livestock was about 95 litres per day during summer and 62 litres per day during winter.
- There were 13 springs including 2 dried springs in Railakot Village (Table-6). Other sources of water in village water supply through pipe lines provided by *Jal Sansthan* and SWAJAL from outside of village sources. Total available water in the village was more than total demand but residents of two hamlets Syuda and Dobatiya were suffering from severe water shortage. So Hamlet wise water availability and management studies are required in this region.

***Summary of Completed Project / Activity***

### Snow and Glacier Studies in the Sikkim Himalaya *(Collaborative project with Space Application Centre, Ahmedabad, funded by Ministry of Environment and Forests, Govt. of India)*

The Snow and Glacier Studies in the Sikkim Himalaya, was carried out in the Tista basin. In this project, an inventory of glaciers and the loss in glaciated area of 57 glaciers, located in 57 valleys have been estimated. The remotely sensed data (Indian Remote Sensing Satellites) and the GIS tools were employed to delineate the boundaries of valley glaciers, supported by ground truth. The remotely sensed data used in the glacier inventory were LANDSAT, TM of 1990, IRS-1C, 1D, LISS –III, LISS-IV of 1997 and 2004, respectively. The investigation revealed that the numbers of valley glaciers have remained the same but their area has decreased. The area occupied by these glaciers in 1990, 1997 and 2004 were 415.17 $km^2$, 403.20 $km^2$ and 393.05 $km^2$, respectively.

The monitoring of snow was done using AWiFS data at Space Application Centre, Ahmedabad. An algorithm called NDSI (Normalized Difference Snow Index) was run to calculate the area occupied by the snow cover in the Tista basin. The total loss of area as 2.77 % has been calculated in 7 years (1997~2004) for the 57 valley glaciers of Tista basin. Finally, a glacier index map has been prepared showing 57 valley glaciers in the Tista basin.

***Summary of Completed Project / Activity***

### Snow and Glacier Studies in the Uttrakhand Kumaun Himalaya *(Collaborative project with Space Application Centre, Ahmedabad, funded by Ministry of Environment and Forests, Govt. of India)*

The Snow and Glacier Studies in the Kumaun region of Himalaya were carried out in Dhauliganga basin of Uttarakhand, western Himalaya. Dhauliganga is a main river flowing through the basin. The total area covered by Dhauliganga basin is 3569.40 $km^2$. An inventory of glacier was prepared and the loss in area of 104 valley glaciers has been estimated. The elevation of the basin ranges from 600 to 6600 meters. The basin is distributed in Survey of India Topographical Sheets (SoI) Nos. 62 (B/6, B/7, B/8, B/9, B/11, B/12, B/13, B/15, B/16) and 62(F/4). The remotely sensed data (Indian Remote Sensing Satellites) and the GIS tools were employed to delineate the boundaries of valley glaciers, supported by ground truth. The remotely sensed data used in the

glacier inventory were of years 1962 and 2005. Total loss in area of 104 glaciers has been calculated using SoI (1962-63) and satellite data of 2005 based on visual interpretation keys. The investigation revealed that the numbers of valley glaciers have remained unchanged, but their area has decreased. The area occupied by these glaciers in 1962 and 2005 were 428.84 $km^2$ and 362.44 $km^2$, respectively. The interpretation of maps shows 15.48 % net loss in glaciated area in Dhauliganga basin.

***Summary of Completed Project / Activity***

## Geohydrological Studies and Quantification of Sediment Load of Thelu (Gangotri Glacier system) Uttarakhand Himalaya *(Funded by DST, New Delhi)*

The Himalaya has direct influence on climate control, regional hydrology and environment of the Indian subcontinent. About 17 % of its mountain area is covered by the glaciers; at present the Himalayan glaciers are retreating. Gangotri glacier, one of the biggest glaciers of the Himalaya, has receded at the rate of ~ 12 m/year between 2004- 2007. The recession and overall decrease in the volume of the glacier is adding to the total area of erosion every year. It generates large amount of suspended sediment load, which is carried from the glaciated basin. Geohydrological study and quantification of sediment load was carried out in Thelu glacier, a tributary glacier of Gangotri glacier. Discharge and suspended sediment (SS) measurements were done during whole ablation season of the year from May to September in Gangotri, Thelu and Raktvarna glaciers. Melt water discharge of Thelu glacier in four consecutive years (2005, 2006, 2007 and 2009) showed large variations (CV is 0.41, 0.46, 0.20 and 0.44) during ablation season when active melting took place. SS concentration from Thelu was much less in comparison to Gangotri glacier. The higher values of daily discharge and SS were accompanied with high SD values in case of Thelu glacier. Max. SS values were generally recorded with the high discharge events like other glaciers of the region. An attempt was made to develop SS rating curves for this small glacier. Relationship between discharge and suspended sediment load in melt water of Thelu glacier becomes very complex by the occurrence of sub-glacial hydrological events. Levels of discharge that exceed previous flows of the season do not always have impact on sediment flux. Still there was good direct relationship between the quantity of sediment evacuated during a day and discharge volume. These rating curves cannot be generalized for all years.



## Theme

# BIODIVERSITY CONSERVATION AND MANAGEMENT (BCM)

The scale of biodiversity is immense and investment is required to bridge crucial knowledge gaps and synthesizing existing information. In this context, the recognition and characterization of biodiversity depends critically on taxonomical, genetic and ecological studies. The attributes such as topographic heterogeneity, habitat productivity and structural complexity allow prediction of biodiversity. The long-term research sites and programmes provide essential information on how biodiversity changes. Human dependence on biodiversity and assessment of economic value of biodiversity have emerged an critical issues, human induced activities w.r.t. biodiversity loss and global climate change as well. This has necessitated assessment and monitoring of biodiversity at different levels and socio-climatic regimes. Biodiversity conservation measures such as establishment and maintenance of live repositories and outreach in different eco climatic zones will help in ensuring quality planting material for the promotion of conservation programmes, and enhancement of the capabilities of the stakeholders at local, regional, state and national levels. Realizing the overall importance of biodiversity for sustainable development and environmental conservation, the Biodiversity Conservation and Management (BCM) group envisages the following objectives: i) To assess, valuate, prioritize, map and monitor biodiversity of the protected and unprotected areas at gene, species and ecosystem levels across the IHR for understanding the status, availability, potential and patterns; ii) To evaluate response of Himalayan biodiversity under changing climatic conditions across the IHR; iii) To develop packages of practices for maintenance and optimal use of sensitive biodiversity components and improvement of bio-resource based livelihood options for indigenous communities; iv) To establish and maintain live repositories (Arboreta, Herbal Gardens, Nurseries, etc.) in different agro climatic zones across the IHR for ensuring the availability of quality planting material; and v) To sensitize diverse stakeholders and building partnerships to develop and demonstrate best practices of management and optimal use of biodiversity components

### Response Assessment and Processing of Knowledge Base to Serve Long-term Management and Use of Biodiversity in the Himalaya - Focus on Representative Protected Sites *(2007-2012, In-house)*

Considering that the world's mountain ecosystems are undergoing rapid environmental changes thereby affecting their overall integrity and life support values, the need for better understanding the response patterns and implementation of multidisciplinary approach to address the issues has been globally realized. While considering approach for effective implementation of such strategy, the Mountain Protected Areas (MPAs) have emerged as global priority sites and are being used as an 'early warning' system. In this context, this project seeks to define appropriate mid to long term management regimes that maintain the multiple functions of MPAs as a major challenge to the management of integrity and diversity of representative ecosystems. The study has been conducted in Nanda Devi Biosphere Reserve of West Himalaya; Nargu Wildlife Sanctuary of North West Himalaya and Kanchendzonga Biosphere Reserve of Central Himalaya and a proposed Tawang Kameng Biosphere Reserve in eastern Himalaya to explore the comparative biodiversity scenarios in selected sites which can be used for wider generalization in the region.

### Objectives

- Synthesis and use of information on biodiversity components of selected areas.
- Investigations on recruitment trends and compositional patterns of forest communities along altitudinal gradient.
- Understanding use patterns of resources by the inhabitants.
- Identify and prioritize human wildlife conflicts.
- Study the grazing competition among livestock and wild ungulates.
- Determine the livestock depredation and retaliatory killing of wild carnivores.

- Identify threat categories of the biodiversity.
- Suggest policy interventions with a view of general applicability; and (ix) drawing comprehensive biodiversity management plan(s) for alternative scenarios

## Achievements

### *Nanda Devi Biosphere Reseve (NDBR), Uttarakhand*

- Preliminary analysis of revisit surveys in target site (i.e. Pindari catchment area year 1988 versus 2008-09) revealed that at community level and across altitude range seedling and sapling layers exhibit increasing trends of species richness and density, which is indicative of likely changes in forest communities in future. Some communities showed remarkably higher densities of specific species in seedling layer at lower altitudes (Mixed-Oak deciduous, *Quercus floribunda, Q. semecarpifolia*) and in sapling layer at higher altitudes (*Abies pindrow*, Mixed Abies-Rhododendron-Maple, *Betula utilis*). This would suggest, likely dominance of particular tree species in such forest communities. Further expansion of some communities can be predicted in near future where positive changes (increase) in seedling and sapling layer is greater (Fig. 11).

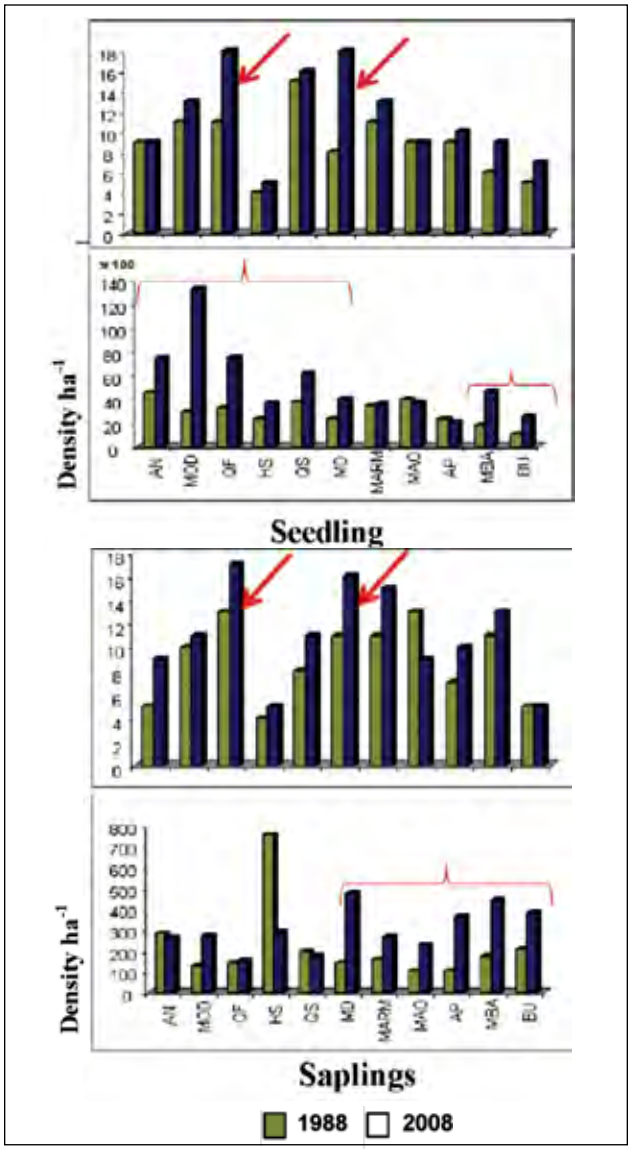



**Fig.11.** Trends in species composition during 1988 and 2008

**An-** *Alnus nepalensis* (2038 m)**; MOD-** Mixed Oak Deciduous (2200 m)**; QF-** *Quercus floribunda* (2400 m)**; HS-** *Hippophae salicifolia* (2475 m)**; QS-** *Quercus semecarpifolia* (2700 m)**; MD-** Mixed deciduous (2725 m)**; MARM-** Mixed Abies-Rhododendron-Maple (2775 m)**; MAO-** Mixed Abies-Oak (2800 m)**; AP-***Abies pindrow* (2950 m)**; MBA-** Mixed Betula-Abies (3200) **; BU-** *Betual utilis* (3300 m)

- Phytosociological study using transect method in alpine areas of Pindari, Kafni and Sunderdhunga valleys showed that of the total 174 species from the study area, Kafni contributed maximum 36% (117 spp.), followed by Pindari - 31% (101 spp.) and Sunderdhunga - 33% (105 sp.) (Fig. 12 a & b). A significant decrease in species richness along the altitudinal gradients ($p<0.01$) in Pindari area was revealing.
- A meeting organized at Madkot, Munsyari (October 05, 2009) yielded Stakeholders perceptions towards conservation and management of Biosphere Reserves.

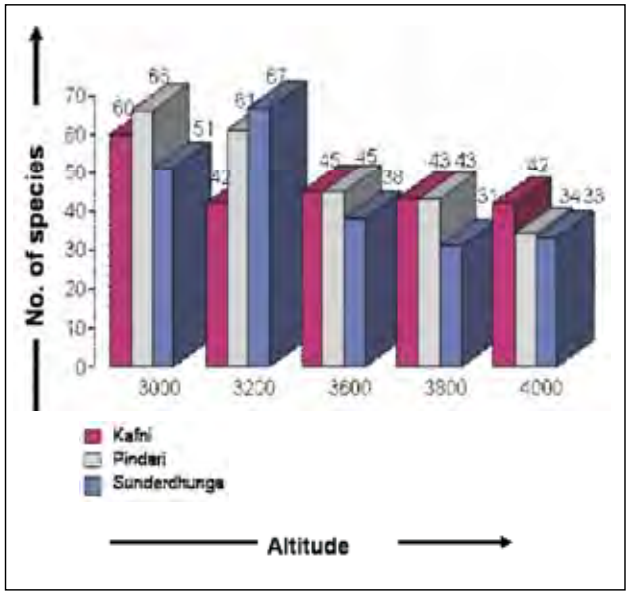



**Fig.12 (a).** Altitude trend of species

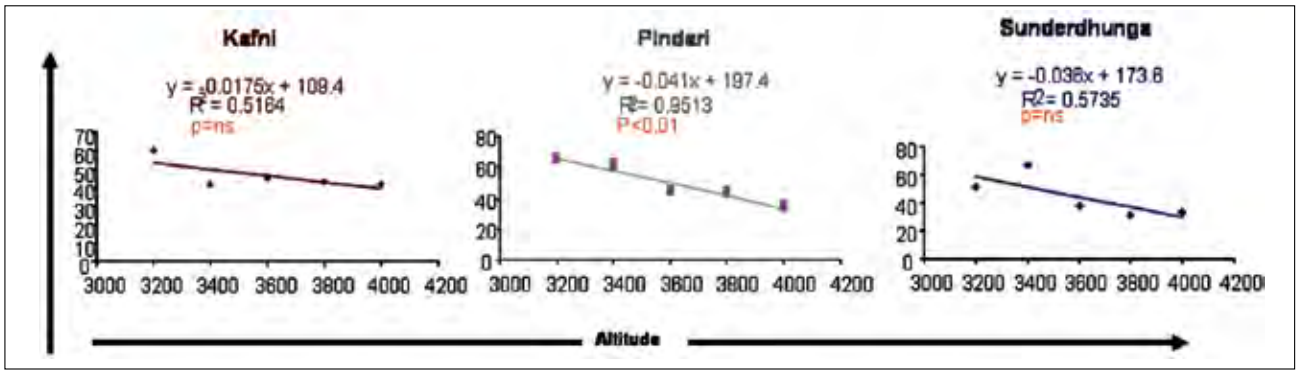



**Fig.12 (b).** Altitude trend of species richness in alpine areas of three valleys.

### *Nargu Wildlife Sanctuary (NWLS), Himachal Pradesh*

- During surveys 95 species of vascular plants were recorded; of these 49 species were native to the Himalayan Region and 22 species near endemic to IHR. 37 sites were sampled between 1328-3488m, and 22 plant communities (Trees: 15, Shrubs: 01 and Herbs: 6) were identified. Total tree density ranged from 80.0-600.0 Ind $ha^{-1}$ and total basal area from 0.2-33.8 $m^2ha^{-1}$. Shrub density ranged from 530.0-9842.0 Ind $ha^{-1}$ (Table-7).
- Of the total 62 species of economically important plants with various uses were medicine (43 spp.), wild edible/food (2 spp.), fodder (15 spp.), fuel (10 spp.), fibre (01 spp.) and various other purposes (4 spp.). Amongst villages, maximum species were extracted as fuel (16 spp.) in Rulang; fodder (20 spp.) in Graman; edible (13 spp.) in Arang; religious (7 sp.each) in Kamand & Arang; timber (09 spp.) in Graman; agricultural tools (14 spp.) in Swar, Graman and medicine (19 spp.) in Swar villages (Fig. 13).
- Fuel extraction trend of the inhabitants was assessed. Mean collection was highest for *Quercus leucotrichophora* (1393.6 kg $household^{-1}$ $year^{-1}$), etc. (Fig. 14).
- Among 16 identified threatend species *Aconitum heterophyllum* and *Malaxis muscifera* were identified as Critically Endangered; *Angelica glauca, Cinnamomum tamala, Dioscorea deltoidea, Polygonatum cirrhifolium, Paris polyphylla, Taxus baccata* subsp. *wallichiana* and *Zanthoxylum armatum* as Endangered and *Rhododendron campanulatum, R. lepidotum, Polygonatum verticillatum, Rheum australe, Valeriana jatamansi* and *Hedychium spicatum* as Vulnerable.
- Data on livestock population were collected, maximum total livestock population was reported in Rulang village (3540), followed by Madhwan (2572), Chunchhal (1189), Panjaund (788) and Jukhan (749) villages.

**Table-7:** Total density of the trees, saplings, seedlings, shrubs and herbs in some identified communities

| Community Types | Density (Ind. $ha^{-1}$, for herbs Ind. $m^{-2}$) | | | | |
|---|---|---|---|---|---|
| **Tree Communities** | **Trees** | **Saplings** | **Seedlings** | **Shrubs** | **Herbs** |
| *Alnus nitida* | 230.0 | 190.0 | 380.0 | 3370.0 | 41.0 |
| *Alnus nitida-Quercus leucotrichophora* mixed | 270.0 | 140.0 | 390.0 | 2680.0 | 94.8 |
| *Aesculus indica-Persea duthiei* mixed | 420.0 | 240.0 | 580.0 | 2565.0 | 69.1 |
| *Abies pindrow* | 210.0 | 50.0 | 480.0 | 2270.0 | 73.7 |
| *Lyonia ovalifolia* | 410.0 | 110.0 | 440.0 | 810.0 | 59.5 |
| *Myrica esculenta-Sapium insigne* mixed | 80.0 | 90.0 | 220.0 | 5330.0 | 100.3 |
| *Neolitsea pallens* | 490.0 | 260.0 | 810.0 | 2180.0 | 88.2 |
| *Neolitsea pallens-Picea smithiana* mixed | 440.0 | 340.0 | 750.0 | 1310.0 | 47.3 |
| *Pinus roxburghii* | 560.0 | 70.0 | 120.0 | 530.0 | 42.2 |
| *Quercus leucotrichophora* | 561.7 | 356.7 | 907.6 | 9842.5 | 59.1 |
| *Quercus leucotrichophora-Neolitsea pallens* mixed | 320.0 | 320.0 | 730.0 | 1680.0 | 57.7 |
| *Quercus leucotrichophora-Rhododendron arboreum* mixed | 430.0 | 310.0 | 710.0 | 1894.0 | 57.3 |
| *Quercus semecarpifolia* | 563.3 | 238.3 | 315.0 | 2050.0 | 89.9 |
| *Rhododendron arboreum-Quercus leucotrichophora* mixed | 450.0 | 210.0 | 550.0 | 2320.0 | 82.3 |
| *Rhododendron arboreum-Lyonia ovalifolia* mixed | 600.0 | 170.0 | 610.0 | 2180.0 | 58.9 |

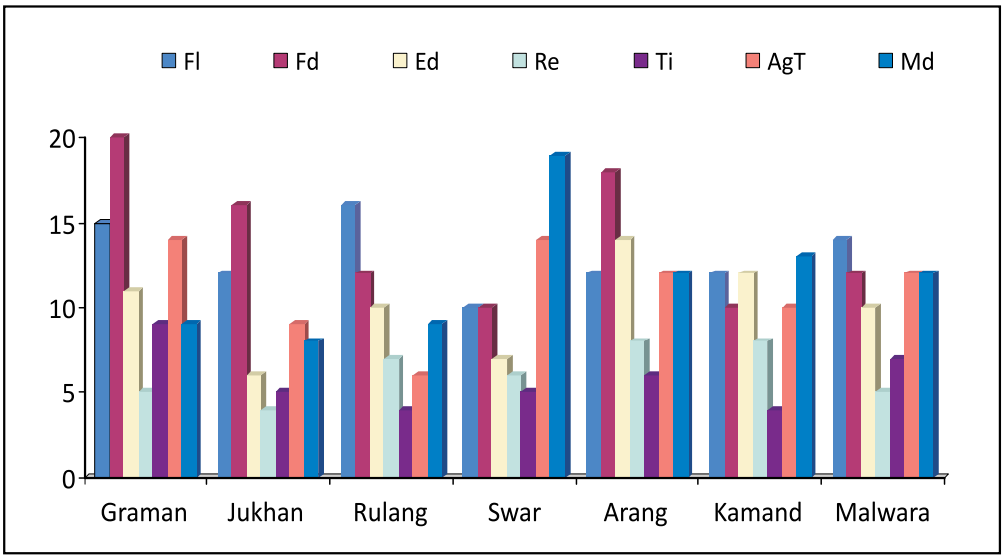



**Fig.13.** Utilization pattern of the economically important species in target villages of Nargu Wildlife Sanctuary

[**Abbreviations used:** Fl=Fuel; Fd=Fodder; Re=Religious; Ed=Edible; Ti=Timber; AgT=Agricultural tools; and Md=Medicinal]

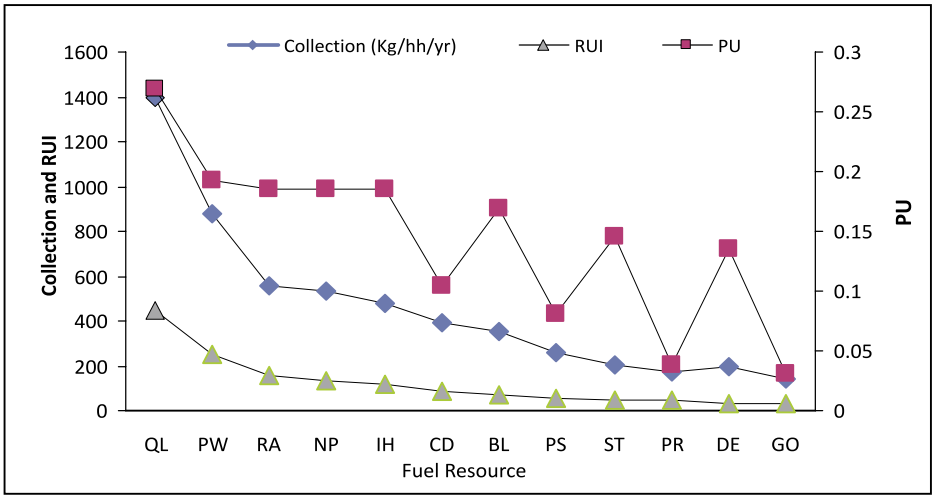



**Fig.14.** Quantum collection, Probability of Use (PU) and Resource Use Index (RUI) of twelve preferred fuel wood species

[**Abbreviations Used:** QL=*Quercus leucotrichophora;* PW=*Pinus wallichiana;* RA=*Rhododendron arboreum;* NP=*Neolitsea pallens;* IH=*Indigofera heterantha;* CD=*Cedrus deodara;* PS=*Picea smithiana;* BL=*Berberis lycium;* ST=*Sorbaria tomentosa* and DE=*Desmodium elegans*]

### *Khangchendzonga Biosphere Reserve (KBR), Sikkim*

- Study recorded 51 woody species, compared to 32 recorded from the Yuksam-Dzongri transect (south-west KBR); Low species diversity index (1.07) was recorded compared to 2.04 (close) and 5.52 (open canopy) in lower forest but high species diversity (3.21) in upper forest compared to 2.8 (close) and 2.5 (open canopy) in earlier studies. (Fig. 15).

- From Tholung-Kisong transect, in south-east KBR for Trees- adults (E category) recorded highest density. Floral species in site 1 were completely different from site 6 and 7. Site 3 and 6 showed maximum of 50% species similarity. Species diversity (r = -0.257), richness (r = -0.901; $p<0.01$) and evenness (r = -0.031) negatively correlated with altitude. Recruitment density was higher for site 1 (54200 ind. $ha^{-1}$) followed by site 2 (33633 ind. $ha^{-1}$) and site 4 (21800 ind. $ha^{-1}$).

- Of the 124 *ethnomedicinal plants* documented for south-west KBR, herbs (47.58%) were most used, followed by trees (32.26%), shrubs (10.48%) and climbers (9.68%) to cure 77 ailments. On part used, roots, rhizomes and bulbs combined topped (38 species). Study documented 77 wild edible species (31 trees, 23 herbs, 12 mushrooms, 5 climbers, and 3 each as shrubs and grasses). Of total 54.17% species were marketed.

- A consultation workshop of stakeholders on 'Biodiversity Conservation and Management in KBR' organized by GBPIHED, Sikkim Unit (collaboration: FEWMD, Govt. of Sikkim) in W. Sikkim. Over 80 participants representing various stakeholder groups made intensive interactions on KBR issues (Fig. 16).

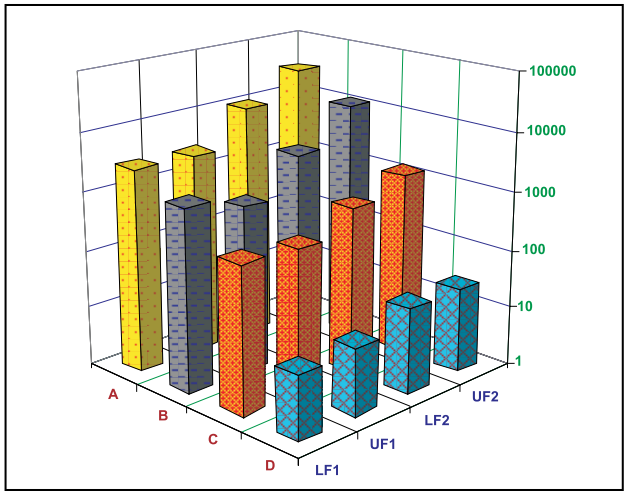



**Fig.15.** Comparative analysis of present study along Yuksam-Dzongri transects (south-west KBR) with earlier studies. A: seedling regeneration ($ha^{-1}$); B: sapling regeneration ($ha^{-1}$); C: tree density ($ha^{-1}$); D: regenerating specie number (per site); LF1: Lower forest (Chettri et al., 2002); LF2: Lower forest (present study); UF1: Upper forest (Chettri et al., 2002); UF2: Upper forest (present study)

**Fig.16.** Stakeholders' consultation workshop for KBR (Sikkim)

### *Tawang-West Kameng Biosphere Reserve (proposed), Arunachal Pradesh*

- Information on demographic profile, habitat map, land use / cover, agricultural practices and cropping pattern, horticultural crops, livestock types, flora and fauna was generated for the development of database.

- *Monpa, Sherdukpen, Khowa, Aka*, and *Miji* are the tribes inhabiting the Tawang and West Kameng (Biosphere Reserve) are dependent on agricultural and horticultural species, NTFP's and livestock as the chief source of their livelihood. Paddy, wheat, maize, millet, pulses, oilseeds, potato, ginger, turmeric, chilies and vegetables are the major agricultural crops (Fig. 17). While the horticultural crops include apple, walnut, kiwi, citrus, banana, ginger, etc. The livestock types are Cattle, Buffalo, Yak, ZO-ZOMO, Mithun, Sheep, Duck, Horse/Ponies, Pig, Dog, Poultry and Goat. Based on secondary information habitat map, land use/cover, forest types (NRA, 2003) are recorded.

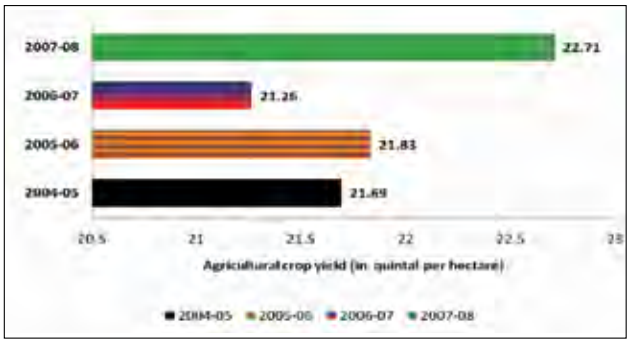



**Fig.17.** Agricultural crops, yield and production in selected areas of Tawang and West Kameng [Source: Department of Agriculture, Arunachal Pradesh. Area in Hect. & Production in MT]

- The study recorded angiosperms (296 spp.), gymnosperms (12 spp.), pteridophytes (7spp.) and lichens (11 spp.). Besides, 57 of ethno medicinal plants have been recorded.

- 40 species of mammals belonging to 34 genera, 18 families, 8 orders were recorded. 10 species are of high conservation importance globally, being listed either as endangered or vulnerable in the IUCN Red list of threatened species.

### Conservation and sustainable utilization of medicinal plants in Himachal Pradesh, North Western Himalaya *(2007-2012, In-house)*

The Himalayan Region has been identified as one of the richest habitats for medicinal plants. In the region, most medicinal plants are being extracted for drug, pharmaceutical industries and oils. Majority of the medicinal plants are also used in Ayurvedic, Unani, Tibetan and other traditional systems of medicine. With the increasing world demand and renewed global interest in traditional ethnopharmacy coupled with the increasing preference for natural substances in the health care system, the natural stock of medicinal plants of Indian Himalayan Region (IHR) is under tremendous pressure. The State, Himachal is being seen as a herbal state and medicinal plants as a major sources of income generation

for the inhabitants. The Kullu and Lahaul & Spiti districts of the State are rich in medicinal plant diversity. There is plenty scope for the promotion of medicinal plants cultivation and conservation. As such an integrated study on conservation and sustainable utilization of the medicinal plants has not been carried out so far. Therefore, the Upper Banjar Valley (1500-3600), Mohal Khad Watershed (1,200-3,000m); Parbati Watershed (1,100- 6,500m) and Upper Beas Valley (2,300- 5,000m) in Kullu district and Chandra Valley (3,300-5,000m) in Lahaul & Spiti districts have been selected to conduct studies on conservation and sustainable utilization of medicinal plants.

## Objectives

- To assess, monitor and map the medicinal plant diversity
- To valuate medicinal plant diversity
- To assess the medicinal plant diversity for threat categories
- To prioritize potential medicinal plants for conservation and socio-economic development of the inhabitants
- To develop conventional propagation protocols and agrotechniques for the potential medicinal plants
- To develop strategies and promote ex-situ and in-situ conservation of medicinal plants
- To impart training to different stakeholders on conservation and sustainable utilization of medicinal plants

## Achievements

- Total 476 species of Medicinal Plants (MPs) belonging to 307 genera and 101 families were recorded. From Chandra Valley total 307 MPs, 127 natives and 102 endemics/near endemics, Upper Beas Valley total 384 MPs, 176 natives and 109 endemics/near endemics, Mohal Khad Watershed 325 MPs, 87 natives and 50 endemics/near endemics, Parbati Valley 422 MPs, 206 natives and 90 endemics/near endemics and in Upper Banjar Valley 388 MPs, 187 natives and 90 endemics/near endemics were recorded.

- 57 sites in Upper Banjar Valley (32); Parbati watershed (13) and Mohal Khad Watershed (12 sites) were surveyed and sampled for the quantification of medicinal plants and associate species. Population of seventeen (17) threatened medicinal plants were assessed and mapped. Among the species, *Angelica glauca* Edgew. was represented in the Banjar Valley (7 sites) and Parvati Watershed (3 sites); *Hippophae salicifolia* in 04 sites in Parbati Watershed, *Podophyllum hexandrum* in 7 sites in Upper Banjar Valley and Parbati Watershed 3 sites and *Taxus baccata* subsp. *wallichiana* in 12 sites in Upper Banjar Valley and Mohal Khad Watershed and Parbati Watershed 01 site, each. For each species relative density and associate species were analyzed.

- Seeds/cuttings of 20 medicinal plants were collected and sown in the nurseries at Mohal and Kasol and herbal gardens at Mohal and Doharanala and, seed germination monitored. 13,000 seedlings/plantlets of 23 medicinal plants at Doharanala, Kasol and Mohal were developed, planted and distributed to different stakeholders. Agrotechniques developed for the 26 high value commercially viable species were disseminated to different stakeholders for the promotion of cultivation of medicinal plants. More than 1500 stakeholders including Line Departments, Forest Guards, ITBP, SSB Officers and soldiers, Students, Teachers, Panchayat Members, Farmers, NGO's, Mahila Mandal, etc. were educated through exposure visits organized on various occasions (Fig. 18 a-b).


**Fig.18 (a-b).** Exposure visits of different stakeholders at Himachal Unit Mohal-Kullu, Himachal Pradesh

**Fig.19.** *Withania somnifera* **cultivation in Kullu valley by the farmers**

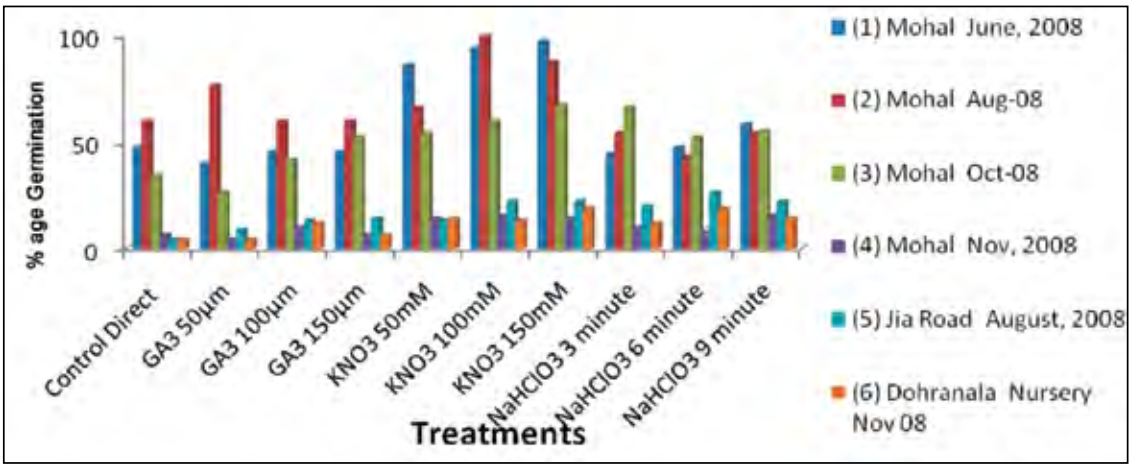



**Fig.20.** Seed germination (%) of Withania somnifera collected in different seasons

- Over 1000 seedlings of *Withania somnifera* were given to various stakeholder groups for cultivation and for wast land management. On an average the survival was nearly 90% (Fig. 19).
- Seeds of *Withania somnifera* collected in August, June, October and November from Mohal medicinal plants nursery Jia and Dohranala were tested for seed germination trials under different treatments. Seeds collected in August showed the best germination (Fig. 20).

## Up-scaling applicability of *ex-situ* mechanisms for conservation and utilization of high value plant species –focusing on promotion of conservation education & capacity buildings *(2007-2012, In-house)*

Conservation and optimal use of high value species has emerged as one of the priority agenda of research and development realizing the fact that it can serve the basic needs of human being together with maintaining the biodiversity. Indian Himalayan Region occupies a significant position in the world as far as biodiversity is concerned. The propagation protocols need to be further put to test their efficacy and up scale the applicability in the field condition through promotion of conservation education and capacity building in the IHR. In the Himalayan context, this activity assumes greater significance in view of the rapid loss of biodiversity. Capacity building of the stakeholders on conservation education through field demonstrations. The work therefore integrates the Conservation Education and promotion of ex-situ mechanisms of conservation and use to up-scale the applicability for effective utilization of high value species.

### Objectives

- To apply the ex-situ conservation techniques for developing appropriate technologies of mass multiplication and storage of germplasm for conservation an effective utilization
- To demonstrate and upscale the applicability of existing protocols in selected sites and meet the demand of planting material by different stakeholders
- To ensure the quality planting material through phytochemical and genetic investigation of target species
- To understand the growth responses of the target species in wild as well as the cultivated land
- To develop a centre for on-site training and extension programmes for various stakeholder groups and also as a place for nature interpretation
- To inculcate among students excitement of understanding and working on different aspects of biodiversity conservation and encourage them to pursue higher studies in the biodiversity conservation

### Achievements

#### *Himachal Pradesh-Himachal Unit*

- In the Arboretum sites 348 seedlings of 18 species of ecologically, economically and of ornamental values were planted and fresh seeds of 7 species of trees and shrubs were collected and stored in the laboratory for the strengthening of nursery. 400 cuttings of Hedge plant (*Euonymus* sp.) and 2440 cuttings of 5 ecologically and economically important species were raised in shade house as well as in open at Mohal and Herbal garden at Dohranala.
- Over 1500 seedlings/plantlets of 10 species were developed. Maximum survival was shown by *Cornus capitata*, *C. macrophylla* and *Acer oblongum* (100%).

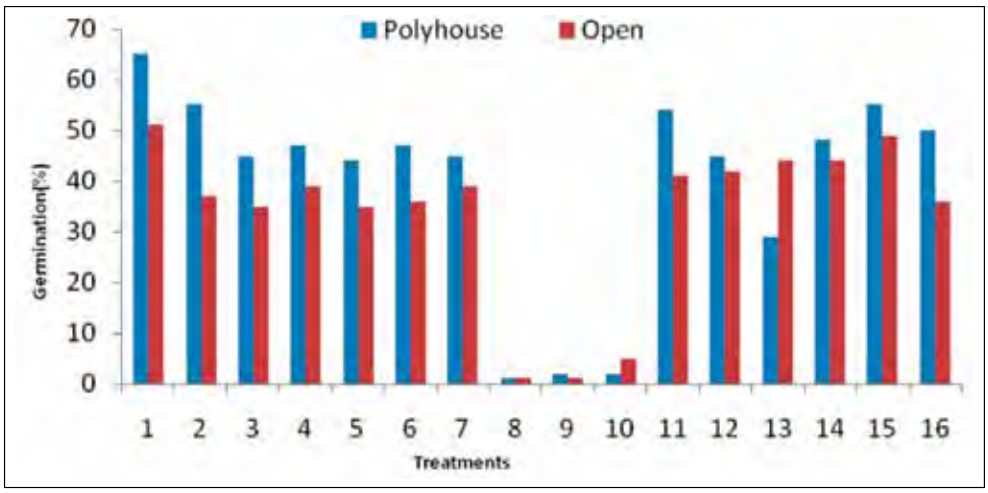



**Fig.21.** Seed germination of Cornus macrophylla in different conditions

[**Abbreviations used:** 1=Control Direct; 2=$H_2SO_4$ 50% 5min; 3= $H_2SO_4$ 50%10min; 4= $H_2SO_4$ 50%15min; 5=$GA_3$ 100 µm; 6=$GA_3$ 200 µm; 7=$GA_3$ 300 µm; 8=$NaHClO_3$ 60minute; 9=$NaHClO_3$ 120 minute; 10=$NaHClO_3$ 180minute; 11=$KNO_3$100 mM; 12= $KNO_3$ 200 mM; 13= $KNO_3$ 300 mM; 14=IBA100 µm; 15=IBA 200 µm; and 16=IBA 300 µm]


**Fig.22.** Participants during training programme: (a) Stakeholder involvement; (b) Expert lecture

219 seedlings of 7 tree species were planted in the 3rd class forest land with the participation of Mahila Mandals and Forest Department at Mohal. Maximum survival was shown by *Quercus floribunda* (87%).

- Seed germination protocol for the *Cornus macrophylla*, a multipurpose tree was developed in polyhouse as well as in open condition (Fig. 21). Germination results in polyhouse were better than that of the open condition.
- One Day Training Programme on "People's Participation in Weather Monitoring, Climate Change and Biodiversity Conservation" was organized in Govt. Senior Secondary School, Sundernagar, district Mandi (Feb. 26, 2010) for the teachers and students for their capacity building on weather monitoring, climate change and biodiversity conservation and management (Fig. 22a-b). Over 1000 people representing different Government stakeholders were educated through organization of training programmes and exposure visits on various occasions.

### *Uttarakhand –Headquarters*

- In order to apply the *ex situ* conservation techniques for mass propagation, seed germination protocols for different species have been developed. A maximum of 55% seed germination was achieved in *Pleurospermum angelicoides*, which was improved over control (Fig.23).
- Phytochemical investigation on *Valeriana jatamansi* collected from the diversified habitats was performed. Variation in phytochemicals and antioxidant activity in wild and planted plants of *Valeriana jatamansi* was recorded. A significant reduction in total phenols in root part of cultivated individuals (12.79 to 7.66 GAE mg /g) was found but an increase was observed in aerial parts (10.99 to 18.44 GAE mg /g). A significant decrease ($p<0.01$) in antioxidant capacity was recorded in roots of cultivated plants but aerial parts showed significant ($p<0.01$) increase in antioxidant activity.

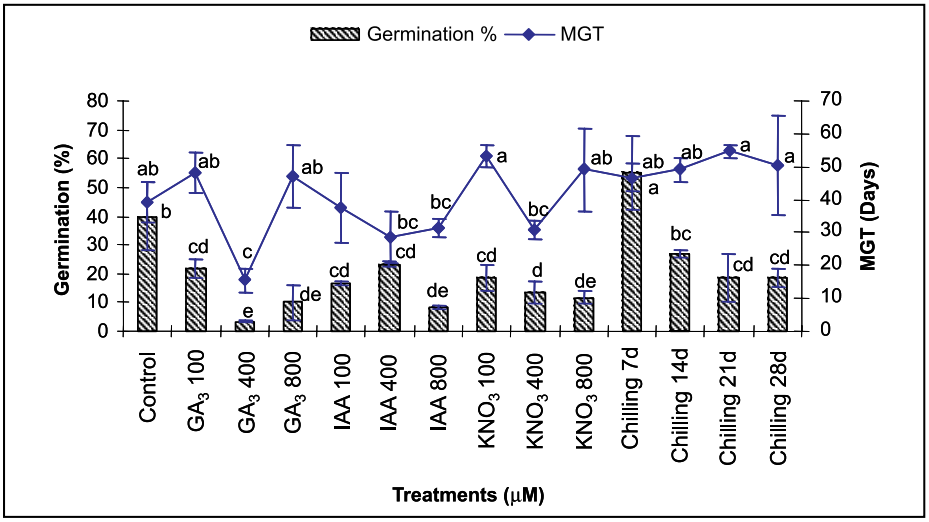



**Fig.23.** Effect of different pre treatments on percent germination and mean germination time of Pleurospermum angelicoides. Control, $T_1$ - $GA_3$ 100, $T_2$ - $GA_3$ 400, $T_3$ - $GA_3$ 800, $T_4$ - IAA 100, $T_5$- IAA 400, $T_6$ - IAA 800, T7 - $KNO_3$ 100, $T_8$ - $KNO_3$ 400, $T_9$ - $KNO_3$ 800 µM, $T_{10}$ - Chilling 7, $T_{11}$ - Chilling 14, $T_{12}$ - Chilling 21, $T_{13}$ - Chilling 28 days



- Genetic diversity of *Valeriana jatamansi* using ISSR markers revealed the variation among populations. Of the 101 ISSR loci tested, 71.29% were polymorphic. The genetic diversity was high (percentage of polymorphic bands, PBB =71.29%; Shannon's information index, I = 0.4 at the population level, but low within individual study populations (PBB = 57.43%; Shannon's information index 0.33). Analysis of molecular variance (ANOVA) indicated that 0.4% of the genetic diversity among the study populations was attributed to geographical location while 99.6% was attributed to differences in their habitats.

- Training workshop to promote outreach through Conservation Education was conducted at G.I.C. Matli Uttarkashi (12 -14 October, 2009). A total of 106 participants from 30 different schools of district Uttarakashi and Tehri participated.

### *Sikkim- Sikkim Unit*

- After 11 months of transplantation, *Michelia excelsa, Symingtonia populnea* and *Eriobotrya petiolata* showed significant plant height increment. Over 2000 *Swertia chirayita* plants (age 1 year) transplanted in nursery beds/bags; > 70% survived; Over 200 plants introduced to *in-situ* conditions. Over 1000 nursery grown plants of *M. excelsa, Juglans regia, E. petiolata, etc.* transplanted and high survival obtained.

- In 11 populations of *Rubia cordifolia*, seed germination was observed using 10 chemical treatments. On average, $GA_3$-125 µM (T5: 62%) and NaHClO-30 min (T5: 60%) appeared most stimulatory over control (T0: 38%; Fig. 24). Individually, populations responded differently. Chemically propagated seedlings of *R. cordifolia* in pool were transplanted in open beds to monitor survival and growth.

- *Pandanus nepalensis* seeds (3 population) were provided 10 pre-soaking chemical treatments. NaHClO (60 min) significantly maximized seedling emergence (57%) over control (19%). $H_2SO_4$ 10min was also stimulatory to emergence. Assessing potential gene bank of *P. nepalensis*, 11 populations have been qualitatively and quantitatively assessed.

- Capacity building Workshop on 'Biodiversity Conservation and Livelihood Options' was organized in south Sikkim; over 70 diversified stakeholders participated (Fig. 25). Important livelihood options emerged and recommendations made. Over 1000 saplings of MPTs (*Michelia excelsa*, *Eriobotrya petiolata, Juglans regia,* etc. were distributed to stakeholders.

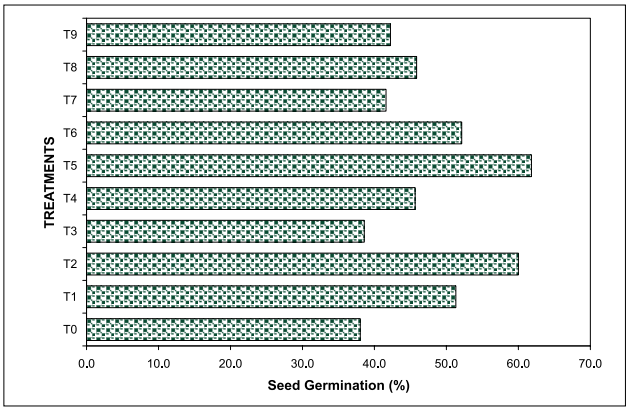



**Fig.24.** Effect of chemical treatments on seed germination in *Rubia cordifolia* (Sikkim)

**Fig.25.** Capacity building workshop in south Sikkim

## Expanding Outreach through Participation of Youth in Real-time/field Observations to Benefit the Education (PROBE) in the Indian Himalayan Region *(2007-2009, DST, New Delhi)*

In view of the unprecedented rate of global climate change and its impacts on biodiversity, it is imperative to make young generation aware on these issues. This is possible only if the subject(s) receive due attention right from the schools. To achieve this, there is a great need of making the science, in particular the nature science, related education interesting and society oriented. However, while considering this we need to incorporate interdisciplinary thinking into it. This can be achieved through an efficient use of the existing infrastructure of formal education. Responding to the need of making science education interesting and useful, Department of Science & Technology (DST) under its Inter-Sect oral Science & Technology Advisory Committee (IS-STAC) took a lead by initiating a scheme on participation of youth in schools for acquisition, generation, use and disseminations of field data. Under the scheme a programme entitled *"Participation of youth in Real time/field Observations to Benefit the Education (PROBE)"* is being implemented in the state of Uttarakhand. The G. B. Pant Institute of Himalayan Environment & Development (GBPIHED), Kosi-Katarmal, as one of the Technical Resource Center (TRC), under U-PROBE has been facilitating execution of programme in the state. The programme was extended in Himachal Pradesh through Himachal Unit in 2008 to educate the students, teachers and develop Technical Resource Centre, at Mohal- Kullu.

### Objectives

- To provide an opportunity for participatory and interactive learning for school children
- To shift emphasis for a student from being a passive recipient of information and knowledge (i.e., downloading) to become an active author of relevant and useful information (i.e., uploading)
- To generate/gather information and convert such information into useful knowledge
- To use data/information gathering as means of generating interest in science
- To bring schools/institutions of higher learning and grassroots community organization into networking relationship
- To create a data base on meteorology, climate, natural resources and related fields of building village/ watershed level data infrastructure
- To contribute to scientific understanding of weather and climate in mountain region and study their local impacts
- To help students in schools reach higher levels of achievements in science education

### Achievements

- 03 Manual Weather Stations were established at GSSS, Panarasa and GSSS Kot-Hatli in district Mandi and GHS, Manglore, district Kullu. Weather of all the stations monitored by the teachers at 8.30 am everyday and maintained in a register. During installation of the weather stations, the teachers and students were trained to handle the instruments and note the data properly from the installed stations in the selected schools of Kullu, Mandi, Bilaspur and Hamirpur Districts. Wheather data were collected from all installed ststions.
- Two one day Training Programmes were organized in Government Senior Secondary School, Goshal, District- Kullu and Government Senior Secondary School, Ghumarwin, District- Bilaspur on "Weather Monitoring, Climate Change and Biodiversity". Different Resource Persons delivered the lectures on Biodiversity in relation to Climate Change; Pollution and climate change; demonstration of Weather monitoring; data collection; Participatory Rural Appraisal exercise in Goshal village, Kullu district and Ghumarwin, Bilaspur district; and Qualitative and quantitative assessment of biodiversity (Fig.26 a-c). Pre training programme feedback and post training programme feedback were taken. The training programme showed significant improvement in the skill of the participants (Fig. 27 a-b).
- Participatory Rural Appraisal (PRA) approach was introduced to the teachers and students during the training programmes. They were trained in the village Ghoshal and Ghumarwin. The Participants were given exposure of Historical Transect Analysis, resource, social and transect mappings, information generation on the natural resource utilization patterns, seasonal and annual calendars of the activities, cropping


**Fig.26.** Various activities of training programme: (a) Demonstration to the students at GSSS Goshal, Kullu; and (b-c) Training programme and PRA exercise at GSSS Ghumarwin, Bilaspur

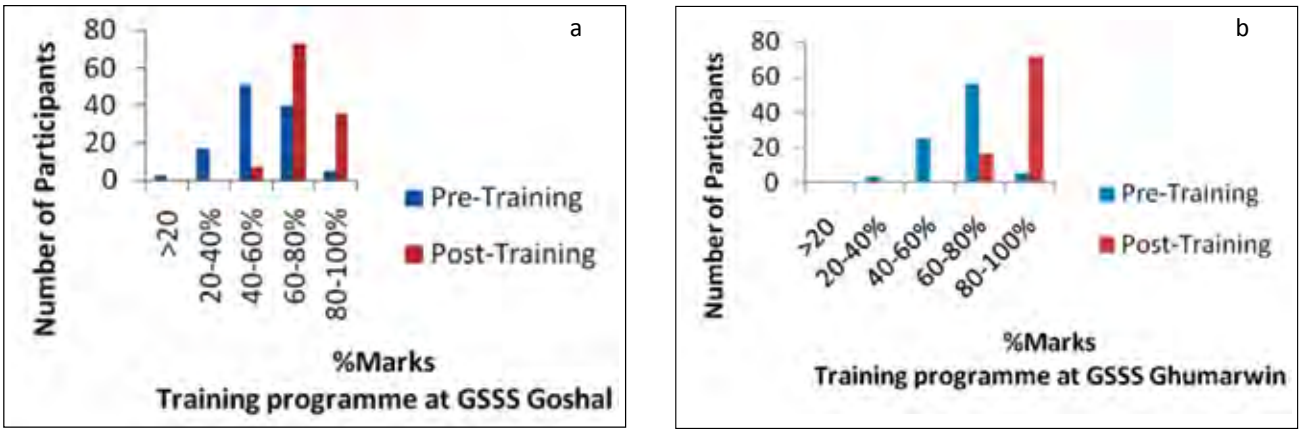



**Fig.27.** Responses of the participants during training programmes; (a) GSSS, Goshal; and (b) GSSS, Ghumarwin



patterns, land use pattern, climate change, etc. They were trained about the validation and authentication of the information through Participatory Rural Appraisal (PRA).

- Seedlings of *Withania somnifera* (Ashwagandha), *Grevillea robusta* (Silver oak), *Pittosporum eriocarpum* (Teera), *Gravillea robusta* and *Quercus leucotrichophora* (Ban) were distributed in the selected schools. The partner Schools were requested to propagate Ashwaghandha in a large scale and distribute to the villagers. So that the villagers also get the benefit of such a high value medicinal plant.

## Study on the Assessment and Conservation Prioritization of Plant Diversity along an Altitudinal Gradient in Himachal Pradesh, Northwest Himalaya

*(2006-2010, DST, New Delhi)*

Conservation of biological diversity has become global concern in view of its rapid depletion. The Indian Himalayan Region (IHR) covering approximately 4, 19,873 km$^2$ area, supports representative, natural, unique and socio-economically important floristic diversity. This may be due to unique topography, diverse habitats and large altitudinal range. Due to the dependence of local communities on plant resources for medicine, food (wild edible), fodder, fuel, timber, making agricultural tools, fiber, religious, etc., the population of many economically important plants is depleting fast. The State Himachal Pradesh which is very well known for its typical topography, large altitudinal range, diverse habitats, representative, natural, unique and socio-economically important biodiversity, is also facing high pressures. Although, the State has been explored by many workers mainly for its floral, ethnobotanical and faunal diversity, and a very few studies have been carried out on quantitative assessment of the vegetation. However, studies integrating different components of floristic diversity and prioritization of habitats, species and communities have not been carried out so far. This has necessitated for initiating biodiversity studies along an altitudinal gradient and present study has been carried out for the first time on these lines in the State.

### Objectives

- To assess plant diversity of the Himachal Pradesh in relation to climate and altitude
- To assess status and distribution pattern of the native and endemic species in relation to climate and altitude
- To study the utilization pattern of plant diversity including indigenous knowledge and practices along an altitudinal gradient
- To identify rarity of the species
- To prioritize potential sites for conservation and high value potential species for socio-economic development of the local communities

## Achievements

- Total tree density, total shrub density, total herb density and total tree basal area of the identified communities in Hirb and Shoja Catchments (HSCs), Chailchowk-Rohanda-Kamrunag Area (CRKA), Ghannahatti - Shimla Forests and Mandi Pandoh Area are presented (Table-8).

- 493 economically important species were recorded from CRKA. These species were utilized by the inhabitants as medicine, fuel wood, fodder, edible, timber, making agricultural tools, religious and miscellaneous purposes (Fig. 28.). Fuel and Fodder extraction trend were analyzed. In HSCs, Resource Use Index (RUI) for the fodder species varied from 1.95 (*Spiraea canescence*)- 946.80 (*Quercus semecarpifolia*) and Fuel species from 0.15 (*Deutzia staminea*)-1494.00 (*Picea smithiana*); in CRKA, RUI for the fodder species varied from 3.88 (*Ficus roxburghii*)- 701.38 (*Quercus leucotrichophora*) and fuel species from 0.68 (*Cotoneaster bacillaris*)-418.28 (*Quercus leucotrichophora*); and in Ghannahatti-Shimla forests, RUI for the fodder species varied from 3.0 (*Ficus roxburghii*)- 1697.8 (*Quercus leucotrichophora*) and fuel species from 2.40 (*Robinia pseudoacacia*)-1622.7 (*Quercus leucotrichophora*) (Fig. 29).

- 137 species belonging to 106 genera and 60 families were identified under different threat categories as Critically Endangered (28 species), Endangered (18 species), Vulnerable (37 species) and Near Threatened (54 species) in HSCs where as in CRKA 118 species belonging to 97 genera and 60 families were identified under different threat categories as Critically Endangered (16 species), Endangered (35 species), Vulnerable (67 species) and Near Threatened (40 species).

- Prioritization of habitats and communities in HSCs and CRKA was done based on Conservation Priority Index (CPI). Amongst habitats, shrubbery, bouldary and shady moist, respectively in the forest zone and alpine moist slope and watercourses, in the alpine zone amongst the forest communities, *Betula utilis, Juglans regia-Picea smithiana* mixed, *Quercus semecarpifolia* and *Quercus semecarpifolia-Taxus baccata* subsp. *wallichiana* mixed communities, Among alpine communities, *Rhododendron anthopogon*, *Rhododendron anthopogon-Cotoneaster microphyllus* mixed and *Spiraea bella-Viburnum grandiflorum* mixed communities were prioritized for conservation in HSCs.

- In CRKA, amongst habitats, shady moist forest, dry forest, reverine and rocky habitats and amongst the communities, *Abies pindrow, Pinus roxburghii*, *Picea smithiana, Quercus leucotrichophora*, *Pinus wallichiana* and *Cedrus deodara* communities, respectively prioritized for conservation based on Conservation Priority Index (CPI).137 species belonging to 106 genera and 60 families were identified under different threat categories as Critically Endangered (28 species), Endangered (18 species), Vulnerable (37 species) and Near Threatened (54 species) in HSCs where as in CRKA 118 species belonging to 97 genera and 60 families were identified under different threat categories as Critically Endangered (16 species), Endangered (35 species), Vulnerable (67 species) and Near Threatened (40 species).

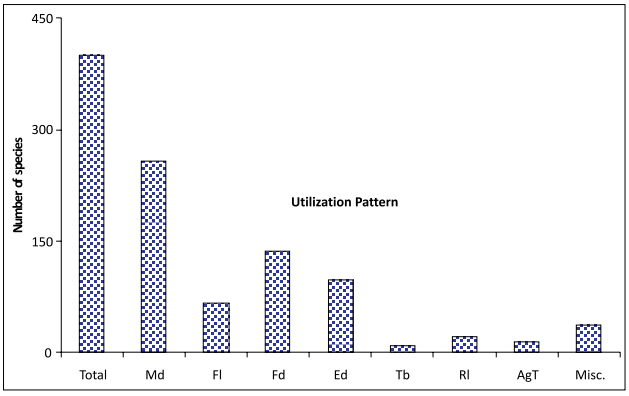



**Fig.28.** Utilization pattern of floristic diversity in CRKA [**Abbreviations:** Md=Medicinal, Fl=Fuel, Fd= Fodder, Ed=Edible, Tb=Timber, Rl=Religious, AgT=Agricultural Tools, Misc.=Miscellaneous]

**Table-8:** Total tree, shrub, herb density range and total basal area range in the different areas

| | HSCs | CRKA | Ghanahatti-Shimla forests | Mandi Pandoh Area |
|---|---|---|---|---|
| Total tree density (Ind $ha^{-1}$) | 60.0-1060.0 | 40.0-560.0 | 130.0-507.3 | 110.0-360.0 |
| Total shrub density (Ind $ha^{-1}$) | 330.0-2470.0 | 250.0-3070.0 | 509.1-3530.0 | 730.0-1610.0 |
| Total herb density (Ind $m^{-2}$) | 54.2-312.6 | 41.7-165.7 | 15.0-96.0 | 20.1-89.45 |
| Total basal area ($m^2$ $ha^{-1}$) | 0.20-83.99 | 0.02-38.16 | 16.51-106.0 | 5.2-66.5 |

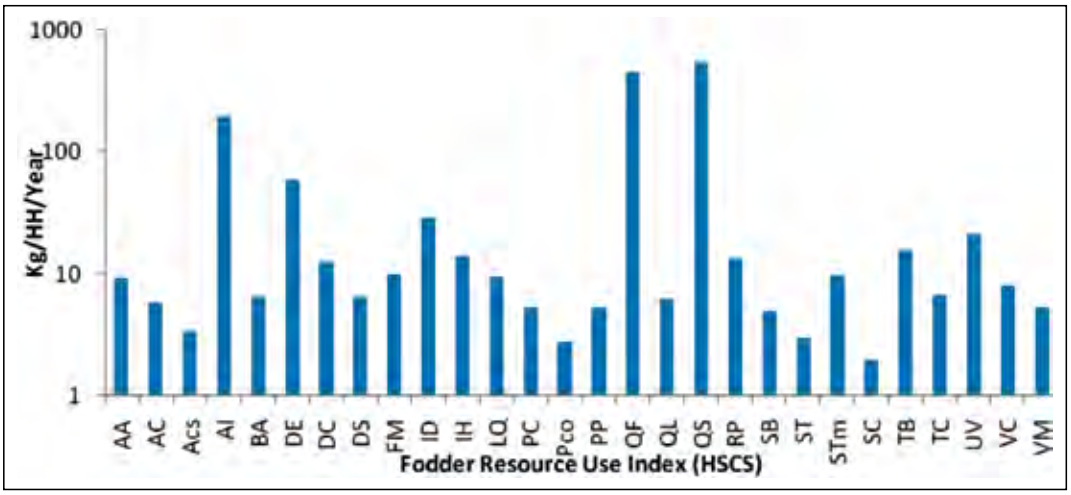



**Fig.29.** Fodder Resource Use Index (RUI) in Hirb and Shoja Catchment

[**Abbreviations used: AA**=*Acer acuminatum*, **AC**=*Acer caesium*, **Acs**=*Acer cappadocicum*, **AI**=*Aesculus indica*, **BA**=*Betula alnoides*, **DE**=*Desmodium elegans*, **DC**=*Deutzia corymbosa*, **DS**=*Deutzia staminea*, **FM**=*Fraxinus micrantha*, **ID**=*Ilex dipyrena*, **IH**=*Indigofera heterantha*, **LQ**=*Lonicera quinculocularis*, **PC**=*Populus ciliata*, **Pco**=*Prunus cornuta*, **PP**=*Pyrus pashia*, **QF**=*Quercus floribunda*, **QL**=*Quercus leucotrichophora*, **QS**=*Quercus semecarpifollia*, **RP**=*Robinia pseudoacacia*, **SB**=*Salix babylonica*, **ST**=*Salix tetrasperma*, **STm**=*Sorbaria tomentosa*, **SC**=*Spiraea cannescens*, **TB**=*Taxus baccata* subsp. *wallichiana*, **TC**=*Toona ciliata*, **UV**=*Ulmus villosa*, **VC**=*Viburnum cotinifolium* and **VM**=*Viburnum mullaha*]



## Evaluation and propagation of two vitality strengthening Astavarga plants of west Himalaya *(2006-2009, NMPB, New Delhi)*

Indiscriminate collection and destructive harvesting of the medicinal plants from the wild have put many valuable plant species in the category of critically endangered, endangered, vulnerable and even extinct. Conservation of such plants has emerged as a common agenda. However, along with the various approaches towards conservation, which include banning of extraction and trade, some indirect approach needs to be developed, which deals with the sustainable utilization of the resources. Development of such approaches need involvement of technology based innovations with high quality research and development investments. In this context, development of suitable propagation packages for mass production of planting materials, analysis of phytochemical properties for quality control and growth response in wild and cultivation are some areas where one can achieve conservation as well sustainable utilization goals.

### Objectives

- To analyze the phytochemical properties within and among population of selected species
- To develop propagation and storage protocols using conventional as well as biotechnological tools for conservation and sustainable utilization
- To maintain the accessions of each individual collected from different localities in gene bank.
- To compare the phytochemical properties of wild with cultivated planting material; and maximize the field transfer of plantlets obtained from elite stock

### Achievements

*In vitro* tuber induction of *Habenaria edgeworthii* was achieved in half-strength MS solid medium supplemented with BA, NAA and $GA_3$ hormone combination. A maximum 75% tuber induction was found treatment T2 (Fig. 30 a). However, the maximum fresh weight (2.38g) and dry weight (0.21g) was observed in medium containing T4 treatment (Fig. 30b). These values were significantly ($p<0.01$) higher than others.

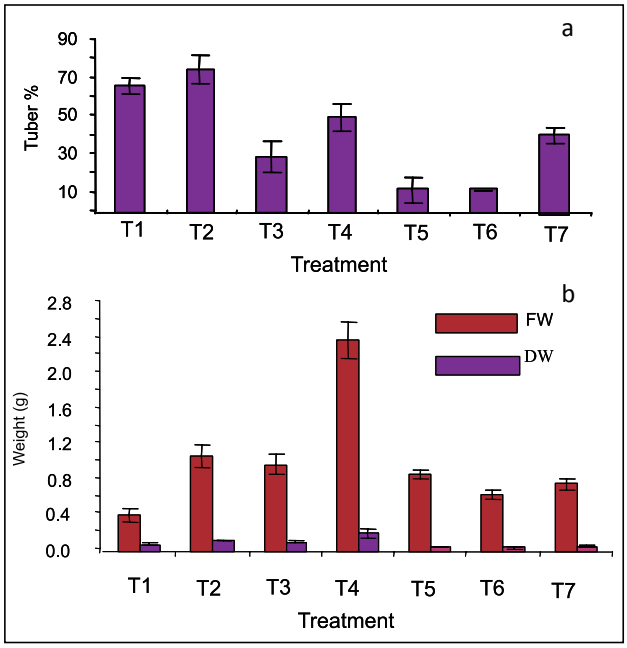



**Fig.30.** Effect of different BA, NAA and $GA_3$ combinations on; (a) tuber %, and (b) weight, of Habenaria edgeworthii

## Population status assessment and screening of active chemical constituents in the selected medicinal plants of Uttaranchal *(2007-2010, UCOST)*

Medicinal plants are of particular interest because they contain variety of phytochemicals and bio-chemicals which could be potential source of new and novel natural antioxidants. It is more important in the context of Himalayan medicinal plants where no or little information is available on the natural source of antioxidants.

### Objectives

- To assess the range of variation (quantitative/ qualitative) in active ingredients of selected medicinal plants
- To optimize the suitable phenophase and best harvesting time in the selected species for optimum production of active ingredients
- To evaluate the potential source of natural antioxidants through the identification of antioxidant activity in extract/isolated compounds by certain bioassay methods
- To maintain the accessions of target species collected from different localities in *ex situ* gene bank

### Achievements

- Seasonal changes in phenolic content and *in vitro* antioxidant activity was analyzed in *Hedychium spicatum*. A total phenol, flavonoids and antioxidant activity was recorded highest in the months of October and November (Fig. 31). Essential oil content ranged between 0.40 – 0.95% of fresh weight and maximum was found in the month of August (0.95% of fresh weight).
- GC analysis of essential oil detected a total of 21 compounds and among these 1,8-cineole (20.03-35.01%), β-eudesmol (16.76-22.17%), Elemol (3.55-9.13%), β-pinene (0.44-1.40%), Linalool (1-10.15%) and Camphene (0.18-0.41%) were the major compounds.

## Development of database of vascular plants of Western Himalaya *(2009-2014, In-house)*

Application of bioinformatics in biodiversity data management and its impact on biological research are now well demonstrated. Biodiversity informatics developed using computational tools represents the collective research efforts and products of the life sciences community throughout the world. At present, some information is accessible through the web, and more is being added regularly. However, currently scientists do not find it easy to exploit the information because of a variety of semantics, interfaces, and data formats used by the underlying data sources. To harness the information resources, their authentication and integration are the main tasks currently faced by the biologists. Keeping in view the vast gap of this Biodiversity Information knowledge, digital database of the Western Himalayan vascular plants is essentially required so that proper utilization of the database is done for developing management plan for the conservation of vascular plants.

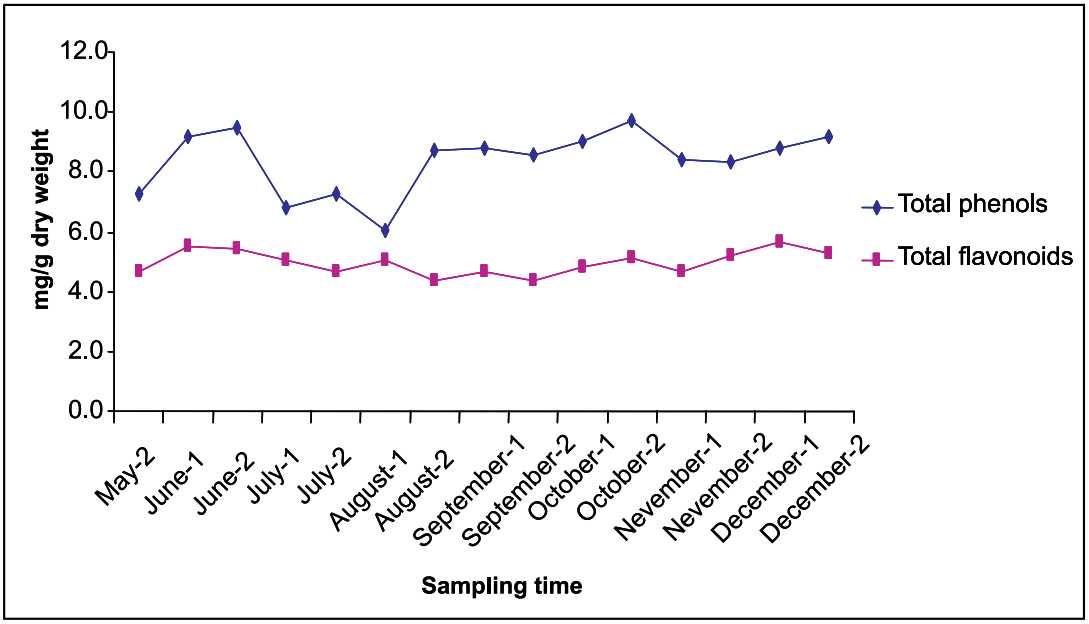



**Fig.31.** Seasonal changes in the total phenol and flavonoid content of Hedychium spicatum

## Objectives

- To develop digital plant database of Western Himalaya through secondary information available in the herbarium and literature.
- To establish web-based inter-linkages with Global Biodiversity Information.

## Achievements

- Documentation and analysis of the plant diversity of Uttarakhand though published information was done (Fig. 32). Digitalization and analysis of 1034 specimens under 621 species, 280 genera and 104 families were done of Uttarakhand State housed in the herbarium of GBPIHED (GBP) (Fig. 33). 420 binomials carefully checked with the relevant floras and monographs and prepared species pages of 105 species which includes information on name of the family, genus, species with authenticated publication details, distribution, medicinal uses, cultivation practices with a note on important observation.
- 205 good quality photographs of plant species have been collected from the Nanda Devi Biosphere Reserve, Uttarakhand for incorporation in species pages. After authentification, the photo images will be included in the data base. 38 medicinal uses of plant information have been gathered from Lata village and are incorporated in the species pages.

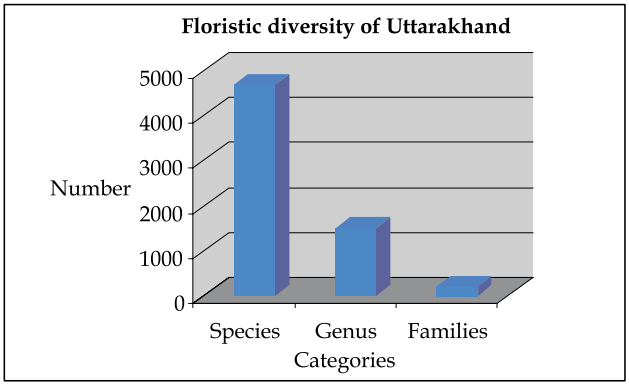



**Fig.32.** Floristic diversity in Uttarakhand

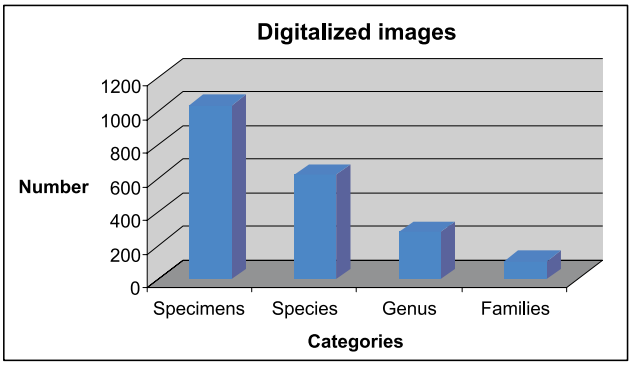



**Fig.33.** Digitalized images in GBP

## Theme

# ENVIRONMENTAL ASSESSMENT AND MANAGEMENT (EAM)

The ever increasing demands of growing population have led over exploitation of natural resources which together have resulted in their scarcity and degradation. The low supply of these resources in presence of high demand has posed high anthropogenic pressure on the already dwindling resources. The degradation of existing resources beyond their carrying capacity therefore leads to a variety of environmental pollutions. Developmental activities and ever increasing load of pollutions need a fresh re-look in a comprehensive manner for sustainable development of a region. Environmental Assessment and Management (EAM) theme focuses primarily on addressing, monitoring, assessing and analyzing physical, biological and cultural components of environment, related to various types of developmental activities/ interventions/ projects/ policies/ plans in the Indian Himalayan Region (IHR). The theme generates information to assess and analyse impacts, set priorities, identify gaps, develop early mitigating approach and to find new technology to achieve a sustainable development of a region. Sustainable utilization of forests and conservation has always been the core issues of sustainable mountain development. As elsewhere, the IHR is one of the most sensitive geographic entities likely to be adversely affected mainly in terms of land use/land cover change due to ever increasing anthropogenic pressure and climate change. The increasing pressure on shrinking forest resources in the IHR and its consequent environmental implications has led to the fundamental need of better understanding about the functioning of the forest ecosystems and a range of goods and services (ES) people obtain from them. Further, how these services valued in monetary terms and the stakeholders in a society paid for the maintenance and flow of these services are essential to affect any conservation approach. The conversion of forest landscapes into developmental purposes (e.g. alternative land uses, infrastructure development, hydropower, etc.) and loss in ES also needs to be assessed for compensation / rehabilitation packages which are so far based on the net present value of these forests. By way of mitigating and minimising adverse impacts of developmental activities and maximising their positive impacts would improve ecosystem services more for making the individuals more self reliant. The recent environmental issues like land use/ land cover change, management of tourism, temperature rise, global warming, climate change, etc. have also become the core topics of the theme to be covered at large. The micro level studies specifically on solid waste problem and its management, aerosols climatology, air and water pollution have been covered under the R&D activities of the theme. Given these facts, EAM theme envisages planning and management options for the sustainable ecological and economic developmental of the IHR. The objectives of the EAM theme are: Assessment and monitoring of physical, biological and socio-economic environmental attributes related to various developmental interventions/policies/plans in the Indian Himalayan Region (IHR); and Development/formulation/suggestion of appropriate management plans ensuring ecological and economic sustainability.

### Forest Ecosystem Services in the Central Himalaya: Quantification and Valuation *(2007-2012, In-house)*

Ecosystem goods and services (ES) represent the benefits people derive, directly or indirectly, from a variety of ecosystem functions. In other words, ES are the conditions and processes through which natural ecosystems and the species make them up, and fulfil supply of goods and services to sustain human life. Ecosystem services are generated through the interaction and exchange between biotic and abiotic components in an ecosystem. They are mainly divisible into (i) provisioning services such as food, forage, timber, bio-fuel, natural fibre, medicinal plants and raw materials for industrial products etc., and (ii) regulating and supporting services such as purification of air and water, mitigation of floods and droughts, detoxification and decomposition of wastes, generation and renewal of soil and soil fertility, pollination

of crops and natural vegetation, aesthetic values, etc. Traditionally these services are considered as free gifts of nature to humankind and therefore the economic value of these services are ignored or under-estimated. This study was initiated to quantify and evaluate selected ES of the two major forest ecosystems of the Central Himalaya, namely, Oak and Pine in the Central Himalayan region where these two forest types are dominant. With an aim to develop a state-of-art methodolog, the present activity therefore focuses at quantification and valuation of ES of selected forests for the assessment and management of these vital natural resources involving household survey in selected locations of the region.

## Objectives

- To quantify and evaluate various ecosystem goods and services accrued from major forest types of the Central Himalayan region.
- To investigate soil formation, soil fertility, soil and water conservation, carbon sequestration value of these forest ecosystems.
- To investigate the impact of these forests on crop field fertility, pollinators, crop yield and crop diversity.
- To develop methodologies and approaches for quantification and valuation of forest ES, and
- To find suitable mechanism and incorporate the findings in the EIA framework for taking informed decision on compensation to the stakeholder groups.

## Achievements

- Resource-use survey in different villages revealed that green fodder collected from trees was maximum in the Oak forests and minimum in Oak-Pine mixed forests (Fig. 34). In contrast, green fodder collected from ground was recorded maximum in Pine forests and minimum in mixed forests. The monetary value of various goods collected from Oak forests was maximum except for the ground fodder, which was maximum for Pine forests (Fig. 35).
- To find out the values for intangible services of forests such as soil and water conservation, availability of water, natural beauty, biodiversity, climate regulation etc., a scoring matrix was developed where the respondents were asked to assign value for these ES out of a highest scale of 10 marks. It was found that Oak forests scored distinctly higher marks as compared to Pine forests in most of the ES. Willingness to pay for ES, such as drinking water and manuring leaves for FYM preparation derived from these two forest types indicated that Oak forests fetch more price than the Pine forests.
- Tree layer diversity (Shannon wiener index) in the two types of forests studied in Lohajang, Chamoli district indicated that Oak forests (1.121) have more diversity as compared to Pine forests (0.133).
- Soil quality of the crop fields adjoining the Oak and Pine forests analyzed in March revealed that the crop fields where Oak leaf litter based FYM was used has better soil quality as compared to Pine forests (Fig. 36).

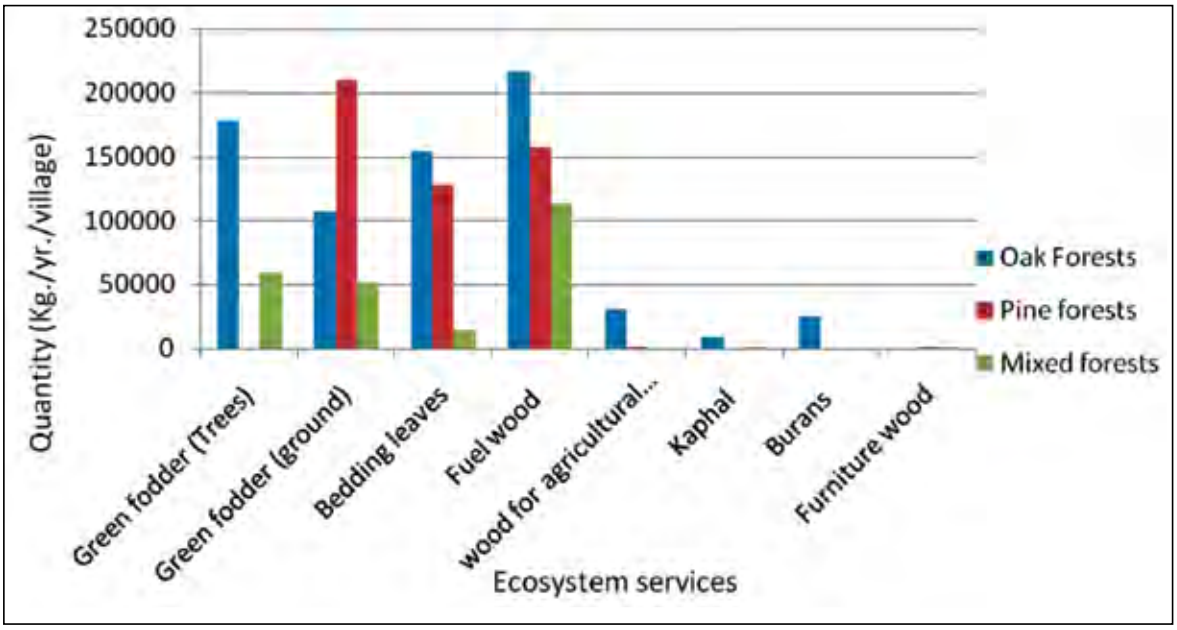



**Fig.34.** Quantity of different goods extracted from the Oak, Pine and mixed Oak-Pine forests in the studied villages (n = 280)

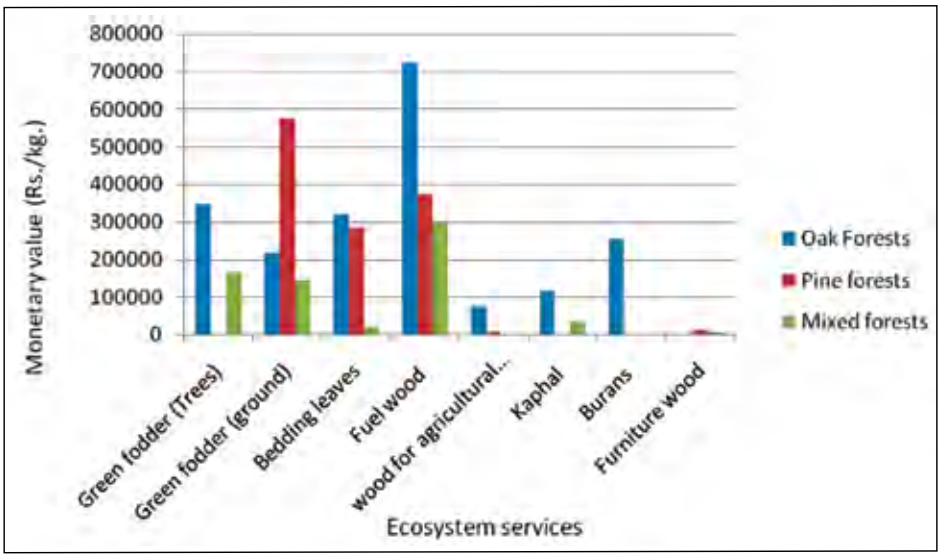



**Fig.35.** Monetary value of different goods extracted from the Oak, Pine and mixed Oak-Pine forests in the studied villages (n= 280)

**Fig.36.** Physico-chemical properties of Oak FYM-based soil (dark brown) and Pine FYM-based cropfield soil (light yellow)



## Strategic Environmental Assessment (SEA) and Environmental Impact Analysis (EIA) of Hydropower projects in Western Himalayan Region *(2007-2012, In-house)*

Hydropower projects, in general, remain in controversy among the local people, environmentalists and social activists due to largely environmental as well as economic concerns. This happens mainly due to lack of attention paid towards these sides by project proponents and in absence of some concrete policy. The project authorities to whom they issue the tenders scarcely verify the construction activities. As a result, lot of anomalies in environmental concerns occur during construction in spite of being conducted Environmental Impact Assessment (EIA) of individual project at its initial stages for environmental clearance. Improper environmental planning and management strategies at individual project level through EIA have raised serious doubts about the sustainability of these upcoming hydropower projects. In many cases, EIA has not been so effective due to lack of application in legislation, weak organizational capacity, lack of training in baseline data generation, inadequate environmental information, low public participation, poor experience sharing, less effective donor policy and lack of policy interventions. SEA looks into cumulative approach. It tends to be more proactive, accounts for the cumulative effects of environmental problems, and initiates and considers all plausible environmentally sound alternatives. Since large number of hydropower projects in the Satluj River Basin in Himachal Pradesh and Alaknanda valley in Uttarakhand are under operation, construction and proposed phases, the present case study is therefore focussed in and around these two basins.

### Objectives

- To overcome the challenges associated with project level EIA process and try to conduct cumulative impact assessment (-ve/+ve) of various hydropower projects

(existing/ proposed) on social, biological, and physical environment initially for one or two river basins and subsequently for entire the western Himalayan region as a whole.

- To develop a GIS database that can be used by project proponents / consultants apart from assisting policy planners to reach to strategic decisions regarding individual projects.
- To suggest the optimal number and types of hydropower projects in such a way that the development should be environmentally viable.
- To incorporate ecological economic based prospecting for compensation of ecosystem services.
- To make recommendations for the MoEF / state government or other alike agencies for modifications or formulations of separate policy / plan

## Achievements

- Himachal Pradesh has 21,452 MW total installed capacity for hydropower development. A case study conducted in River Satluj Basin reveals that more than 27 large, 4 small and 5 micro projects with installed capacity of 9728 MW are likely to develop under HPSEB and private investors. Besides, HIMURJA is planning to develop nearly 69 projects with 279 MW capacity in the same basin.
- Study of seven Environmental Impact Assessment reports showed that the methods of collection for baseline data for EIA study had many gaps. It is due to lack of sound practices of EIA guidelines and legislations. There is no definite protocol for data collection. The recommended terms of reference (TOR) by MoEF need to be followed during report preparation. Besides, peoples' participation is not so satisfactory at the decision-making level.
- The case studies conducted for the Kashang Integrated (243 MW) and Rampur (412 MW) projects (Fig. 37) shows that local peoples were not satisfied with existing mechanism of public hearing. Majority of public demands put forwarded during public hearing were not fulfilled by project proponents. No doubt, compensation was given to the affected peoples but these were not satisfied. Besides, large numbers and large size of the projects are opposed by the respondents. According to perception, the overall environmental management practices being followed by the project proponents not up to the satisfaction level.
- Air quality showed a change during construction phase of the projects (Fig. 38). $PM_{10}$ in the background site at Kashang project was observed maximum (93 µg $m^{-3}$) on January 19, 2010. While in the background site of Rampur project, it was maximum (53 µg $m^{-3}$) on January 22, 2010.
- In Uttarakhand, the total identified hydropower potential is 18,700 MW. According to current estimates, about 145 hydropower projects with a planned power generation capacity of about 14,702 MW are proposed. Of the total identified capacity of hydropower, only 19.13% has been developed so far. While 24.34% of the total capacity is put under construction, and the remaining 56.5% is yet to develop.
- The land use statistics of the Alaknanda catchment and influence zone map was illustrated based on remote sensing data sets of 2004 (Table-9). The total catchment of the River Alaknanda occupied about 6168 $km^2$. Of the total catchment area, about 2344 $km^2$ (37.99 %) area was the snow bound and remaining area of 3825 $km^2$ was covered by different land use/ land cover classes. The maximum area (34.21%) was under the wasteland category whereas 19.12% of the total area was under seven different forest types. Each of the forest categories in varying degree came under the influence zone of the selected 10 hydropower projects in the Alaknanda catchment. Among them, maximum proportion, 79.60 % of the total moist mixed deciduous forest came under the influence zone. While minimum proportion (33.59 %) of pine deodar forest fell under the influence zone.
- The physico-chemical characteristics of the water samples collected from the different locations in the Alaknanda valley. Tapovan is a sampling location where construction work was in progress for Tapovan Vishnugad HEP by NTPC. As a result, high TDS and low DO was found in construction areas compared to other sites.

**Fig.37.** Material preparation for blasting in Rampur hydroelectric project (412 MW)

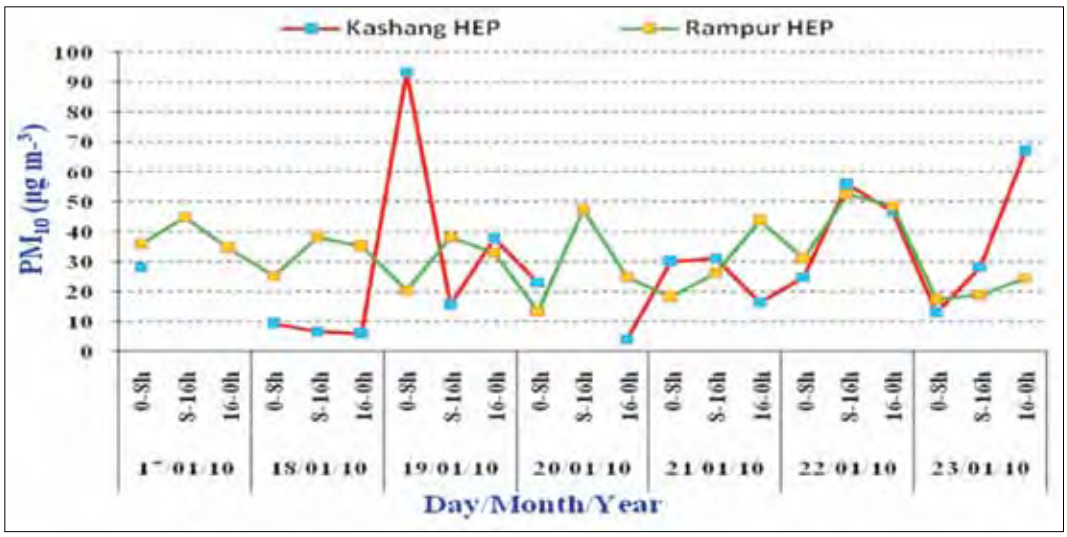



**Fig.38.** Diurnal concentration of $PM_{10}$ during winter season in the background sites of Kashang and Rampur hydroelectric projects

**Table-9:** Land use/land cover statistics of the Alaknanda catchment and influence zone

| Land use/ landcover | Area (km²) | | Area (%) |
|---|---|---|---|
| | Alaknanda catchment | Influence zone | Alaknanda catchment |
| Moist mixed deciduous | 9.02 | 7.18 | 79.60 |
| Pine | 121.62 | 93.08 | 76.53 |
| Pine mix | 107.98 | 75.67 | 70.08 |
| Pine Deodar | 99.99 | 33.59 | 33.59 |
| Deodar | 282.63 | 119.90 | 42.42 |
| Coniferous mix | 475.67 | 214.34 | 45.06 |
| Temperate broad leaved | 81.89 | 27.76 | 33.90 |
| Scrubland | 28.84 | 13.00 | 45.07 |
| Grassland | 384.95 | 215.06 | 55.87 |
| Wasteland | 2110.64 | 641.63 | 30.40 |
| Agriculture | 115.88 | 69.74 | 60.18 |
| Water | 5.75 | 4.53 | 78.78 |
| Snow | 2343.53 | 96.65 | 4.12 |

- Ethanobotanical survey to incorporate ecosystem services in the adversely affected villages of the Alaknanda valley shows that the forest products form an integral part of daily needs of the villagers. Livelihood dependency of the natives from forest produce of the influenced zone was at large.

### Urbanization vis-à-vis solid waste management and air pollution in sprawling urban cities of Himachal Himalaya *(2007-2012, In-house)*

The out migration of population from the villages to urban towns as well as ever growing urban population within these towns and the resultant activities have posed anthropogenic pressure in many towns of the Himalaya. This high anthropogenic pressure causes high load of pollutions. In absence of proper and inadequate infrastructural facilities, some of the human induced pollutions such as solid waste and air pollution have been continuously increasing. Indiscriminate waste throwing and open waste dumping create unhygienic conditions developing a home to breed cockroaches, insects, worms and rats. These later become a cause of many health risks and diseases. Solid waste if dumped openly deteriorates water quality in streams and rivers. Sometimes, the practice of burning waste emits hazardous gases into our atmosphere; as a result ambient air quality (AAQ) also degrades. Besides, biomass burning in the form of fuel wood, coal, etc. also cause AAQ to degrade in the sprawling towns. Keeping in mind alike environmental problems, the study during the reporting period was conducted on solid waste management (SWM) to represent different altitudinal gradients from Siwalik to Trans Himalayan

ranges in Himachal Pradesh in six selected towns, namely, Bilaspur, Kangra, Mandi, Hamirpur, Chamba and Keylong. However, the ambient air quality monitoring (AAQM) study was carried out simultaneously in a campaign mode initially in three towns; Bilaspur, Mandi and Keylong.

## Objectives

- To identify solid waste compositions and its generation.
- To assess the existing waste treatment and disposal facilities available including their adequacy.
- To monitor particulate and gaseous pollutants in ambient air to establish background values.
- To suggest solid waste management and air pollution mitigating plans for policy implications.

## Achievements

- Solid waste characterization study carried out in the six towns of Himachal Pradesh had shown a range from 64.7% biodegradable waste (42.2% readily biodegradable waste (RBW) + 22.5% biodegradable waste (BW)) in Keylong to 78.3% (RBW 53.7 %+ BW 24.6%) in Mandi. Based on existing waste composition, bio-composting for biodegradable waste (RBW+BW), reuse, decorative reuse, and recycling for non biodegradable waste (NBW) were major SWM options.
- The existing solid waste treatment, disposal facilities and their adequacy available with the managing authorities in the towns are very poor which need immediate scientific know how and financial support (Fig. 39).
- The already developed technology (microbial bio-composting) for municipal waste was disseminated after consultative meetings and workshops in the state (Fig.40). The action plans as well as collaboration were executed for religious spot/trekking site such as Bijli Mahadev, picnic spots like Rohtang Pass, Marhi, Solang *nala*, and municipal councils (MCls).
- The AAQM studies conducted at Bilaspur, Mandi and Keylong showed high concentration of particulate pollution compared to gaseous pollution during three seasons of the year 2009-10 at every site. During observations, TSP and $PM_{10}$ have crossed many times their permissible limits (TSP=200 µg $m^{-3}$, $PM_{10}$=100 µg $m^{-3}$ set by CPCB).
- On diurnal basis, highest concentration of TSP and $PM_{10}$ was found between 16 hr IST to midnight followed by 8-16 hr and lowest between midnight to morning 8 hr in all the seasons except in case of TSP at Bilaspur in winter and at Mandi in post-monsoon and winter seasons. During these periods, the increase in TSP at both the sites was found from midnight to up to 16 hr and then a little bit decrease during 16 hr to midnight (Fig. 41). The annual concentration of TSP and $PM_{10}$ was highest as 153.1±8.8 µg $m^{-3}$and 68.8±4.1 µg $m^{-3}$ at Bilaspur (Table-10). Keylong, a site in the cold desert, showed TSP very high compared to $PM_{10}$ during pre-monsoon when the region remained dry and the frequent dust storms were experienced in the region.
- The gaseous pollutants like $SO_2$, $NO_2$ and $NH_3$ were recorded far below the permissible limits (80 µg $m^{-3}$ for $SO_2$ and $NO_2$, and 400 µg $m^{-3}$ for $NH_3$ set by CPCB) at all the study sites. The annual mean concentration of $SO_2$ and $NO_2$ remained highest as 2.4±0.4 µg $m^{-3}$ and 12.2±0.7 µg $m^{-3}$ at Bilaspur and Mandi respectively. However, $NH_3$ remained highest with 24.3±2.3 µg $m^{-3}$ at Mandi (Table-10).
- During winter, the highest concentration of $PM_{10}$ was noticed at Bilaspur (129 µg $m^{-3}$; February 12, 2010; 16-0 hr) whereas in pre-monsoon this highest concentration was at Mandi (111.3 µg $m^{-3}$; June 30, 2009; 16-0 hr), thus was related with HYSPLIT model and Terra MODIS data. It is found that there was a clear-cut indication of this high pollution through long range transport at Mandi. Along the path of the back trajectory, Aerosol Optical Depth (AOD) remained 0.74 to 0.9 at this time. But the highest concentration at Bilaspur was due to both the local as well as external sources where AOD ranged from 0.26 to 0.53.

**Fig.39.** On-site discussion with municipal authorities regarding scientific disposal of solid waste at Bilaspur town


**Fig.40.** Deliberations on 'Municipal Solid Waste Management: Options for Hilly Areas' organized by Himachal Pradesh State Pollution Control Board (SPCB), Shimla

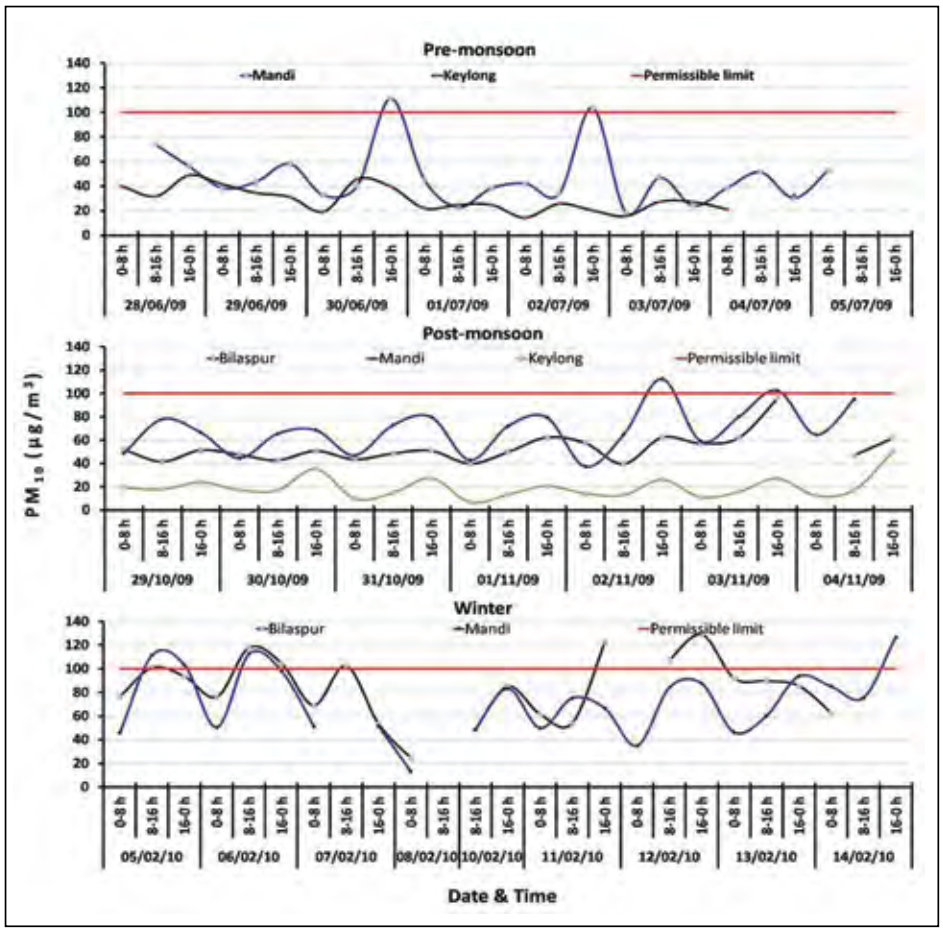



**Fig.41.** Concentration of $PM_{10}$ at Bilaspur, Mandi and Keylong in 2009-10 during pre-monsoon, post-monsoon and winter seasons

**Table-10:** Annual concentration of TSP, $PM_{10}$, $SO_2$, $NO_2$ and $NH_3$ (in µg $m^{-3}$) at Bilaspur, Mandi and Keylong in 2009-10

| Study sites | TSP | $PM_{10}$ | $SO_2$ | $NO_2$ | $NH_3$ |
|---|---|---|---|---|---|
| **Bilaspur** | 153.1±8.8 (n=60) | 68.8±4.1 (n=41) | 2.4±0.4 (n=60) | 12.2±0.7 (n=60) | 19.7±2.1 (n=60) |
| **Mandi** | 140.7±8.9 (n=64) | 63.1±3.3 (n=64) | 0.7±0.1 (n=64) | 10.6±0.6 (n=64) | 24.3±2.3 (n=63) |
| **Keylong** | 123.4±12.4 (n=41) | 24.3±1.7 (n=41) | 1.2±0.2 (n=38) | 2.8±.0.3 (n=41) | 20.6±2.3 (n=39) |

*'n' indicates number of 8 hourly samples analyzed*

## Aerosol climatology over northwestern Indian Himalayan region, Himachal Pradesh *(2005-2011, ISRO Funded Project)*

The aerosols mainly absorb and scatter incoming solar radiation thereby attenuating the solar radiation reaching the ground. Aerosols absorb primarily terrestrial infrared radiation. The phenomena of absorption and scattering from incoming solar radiation alter the radiation budget of the Earth's atmosphere which during a period of time results in climate change. The study of aerosols in the Himalayan perspective is of utmost importance because it will have long term effects such as temperature rise, shifting of vegetation and crops from low altitude to high altitude, glacier melting and resultant criticalities of human adaptability particularly in such a mountain as is topographically fragile and ecologically delicate. Within aerosols, the most anthropogenic aerosols stand Black Carbon (BC). BC is emitted by incomplete combustion of carbonaceous fuel which the dwellers basically in the villages mostly use to meet their energy requirement. This pollutant along with the columnar aerosols is also a matter of great concern among scientific community due to its optically absorbing property. BC absorbs solar radiations in the visible and near infrared wavelengths where most of the solar radiation is distributed. BC has also an ample potential to alter the Earth's radiation budget. Aerosols optical depth (AOD) is a unit for the measurement of columnar aerosols measured through Multi-wavelength Radiometer (MWR) (Fig. 42) while BC is measured through Aethalometer. Mohal, the Himachal Unit of Institute, is the experimental site where these studies are under progress.

**Fig.42.** Multi-wavelength Radiometer (MWR) installed at Mohal-Kullu

## Objectives

- To obtain aerosol optical depth (AOD) at ultra-violet, visible and near infrared spectrums (380-1025 nm) using Multi-wavelength Radiometer (MWR).
- To analyse aerosol size distribution and atmospheric turbidity using Angstrom parameters; α (alpha) and β (beta).
- To obtain black carbon (BC) aerosol concentrations using Aethalometer.
- To assess impact of aerosols on climate change in the Himalayan ecosystem.

## Achievements

- The daily mean forenoon AOD during April 2009 to March 2010 for clear sky days at 500 nm stood to be 0.23±0.01. When analysed on monthly basis, highest AOD at 500 nm was 0.35±0.04 in May 2009. However, its lowest value at the same wavelength was 0.11±0.03 in November 2009 (Fig. 43).
- The daily mean afternoon AOD during clear sky days at 500 nm stood to be 0.36±0.03. On monthly basis, highest AOD at 500 nm was 0.63±0.07 in March 2010. However, its lowest value was 0.20 in January 2010. As far as AOD change is concerned, it was at 500 nm from FN to AN with 54.7%.
- The variations in turbidity parameters (α and β) were noticed inversely related, indicating larger concentration of fine mode particles compared to coarse mode particles and *vice-versa* (Table-11). The more the fine-mode particles, the greater would be their impacts on radiation budget.
- Based on hourly mean values, the concentration of BC was always observed above 2500 ng $m^{-3}$ between 0600 hr to 0900 hr IST. However, the highest ever peak values remained 15657 ng $m^{-3}$ in January 2010 and 15006 ng $m^{-3}$ in December 2009 in bimodal distribution at 0700 hr IST and 1800 hr IST respectively.
- The daily mean BC concentration was maximum with 12246±348 ng $m^{-3}$ on December 30, 2009 and minimum with 1214±30 ng $m^{-3}$ on August 7, 2009. During a period of nine months (July 2009-March-2010), BC mass concentration on monthly mean basis was highest in December 2009 (8008±63 ng $m^{-3}$) due to high amount of biomass burning and lowest in August 2009 (2741±16 ng $m^{-3}$) due to washout effect from rain. Since BC mostly comes from anthropogenic source, it is therefore predominantly from local sources such as biomass burning, forest fires, etc.

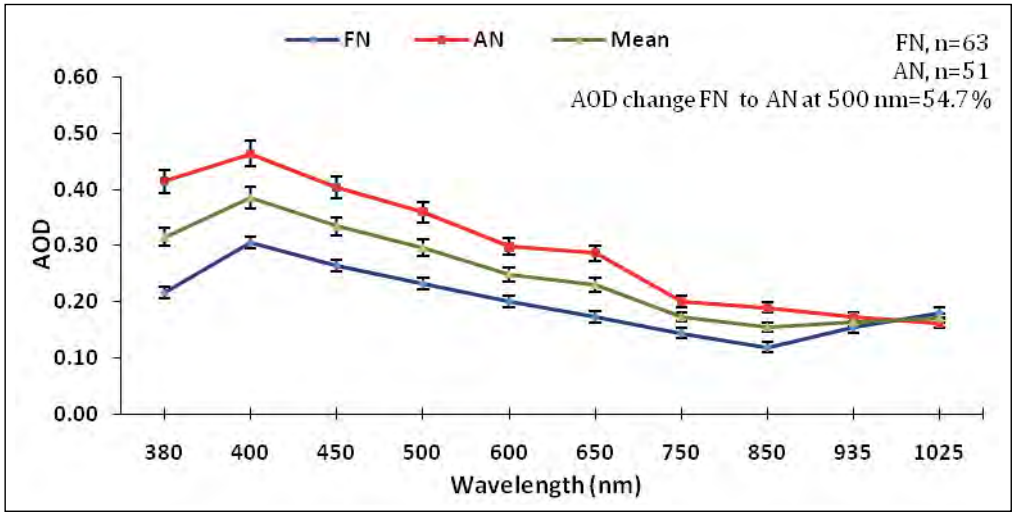



**Fig.43.** Forenoon, afternoon and mean AOD values during April 2009 to March 2010

**Table-11:** Monthly turbidity parameters (α and β) for forenoon and afternoon during April 2009 to March 2010

| Month/Year | Forenoon | | Afternoon | |
|---|---|---|---|---|
| | α | β | α | β |
| April 2009 | 0.39 | 0.12 | 0.64 | 0.15 |
| May 2009 | 0.83 | 0.19 | - | - |
| June 2009 | 0.69 | 0.18 | 0.95 | 0.29 |
| July 2009 | 0.33 | 0.22 | 0.84 | 0.24 |
| August 2009 | 0.38 | 0.24 | 1.81 | 0.08 |
| September 2009 | 0.31 | 0.14 | 1.17 | 0.13 |
| October 2009 | 0.58 | 0.11 | 1.34 | 0.16 |
| November 2009 | 0.87 | 0.05 | 1.62 | 0.12 |
| December 2009 | 1.23 | 0.11 | 1.48 | 0.08 |
| January 2010 | 1.09 | 0.09 | 0.66 | 0.12 |
| February 2010 | 0.83 | 0.09 | - | - |
| March 2010 | 0.47 | 0.18 | 0.53 | 0.38 |

*'-' indicates data not available due to either obscure weather or technical reason*

## Gaseous air pollution in the background site of sprawling urban environment of Himachal Pradesh

*(2008-2013, ISRO Funded Project)*

Gaseous pollutants in ambient air quality have been playing an important role in atmospheric chemistry and recently in global climate change. The trace gases among gaseous pollutants are more concerned since these affect adversely both- the living organism and the Earth's atmosphere. Surface ozone ($O_3$), nitrogen dioxide ($NO_2$), and sulphur dioxide ($SO_2$) have been most important ones among them. Surface ozone is a phytoxic pollutant generated due to anthropogenic emissions in presence of sunlight and nitrogen dioxide concentrations. It adversely affects the human population with a variety of respiratory, skin and other diseases. Similarly, due to surface ozone exposure above 50 ppb for duration of more than 1 hr, it starts to hamper the growth of plants and damages its stomata with yellowing the plants and hence deteriorates its growth and productivity. It is therefore urgent to observe surface ozone episodes in the Himalayan ecosystem which is topographically very fragile and ecologically very delicate. Atmospheric ozone plays an important role in the physio-chemical processes of the troposphere. Besides, it has also strong oxidant properties which at certain level may cause damage to humans, animals and vegetation. Under the present context, measurement of surface ozone concentration has been taken into account using Ozone Analyser (ML9811 Monitor Europe) at Himachal Unit of the Institute- Mohal in the Kullu valley of Himachal Pradesh.

### Objectives

- To measure important concentration of gaseous pollutants such as surface ozone ($O_3$), nitrogen dioxide ($NO_2$) and sulphur dioxide ($SO_2$) due to anthropogenic sources (such as vehicular congestion, and biomass burning) as well as natural sources (dust storms, etc.) to establish background values in the Himalayan region.
- To observe local meteorological parameters and relate these with gaseous pollutants, and analyze in the background of external long range transport sources, and
- To suggest some feasible mitigating measures for policy implications.

### Achievements

- Based on the observations made during year 2009-10 (July-March), ozone episode pinpointed with 77.5 ppb at 1500 hr IST on September 15, 2009 followed by 69.2 ppb at 1500 hr on September 14, 2009 (Fig. 44a).
- Diurnal variation of surface ozone showed low concentration during early morning (<800-900 hr IST) showing an increase during day time (900-1800 hr IST) with a peak at afternoon (1500 hr IST). Afterwards, it continued to decrease gradually during 1800-0800 hr IST (Fig. 44b).
- Based on frequency distribution, hourly ozone concentrations during observation period remained 7 times above 50 ppb. But these values remained 42 times between 41-50 ppb.
- Among the local sources, vehicular emissions and local meteorology have affected positively surface ozone concentrations. During episode day of September 15, 2009, the day temperature was 21.6ºC, humidity 67.3%, wind speed 1.7 km $hr^{-1}$, and large sunshine hour duration (9.2 hours) (Table-12).

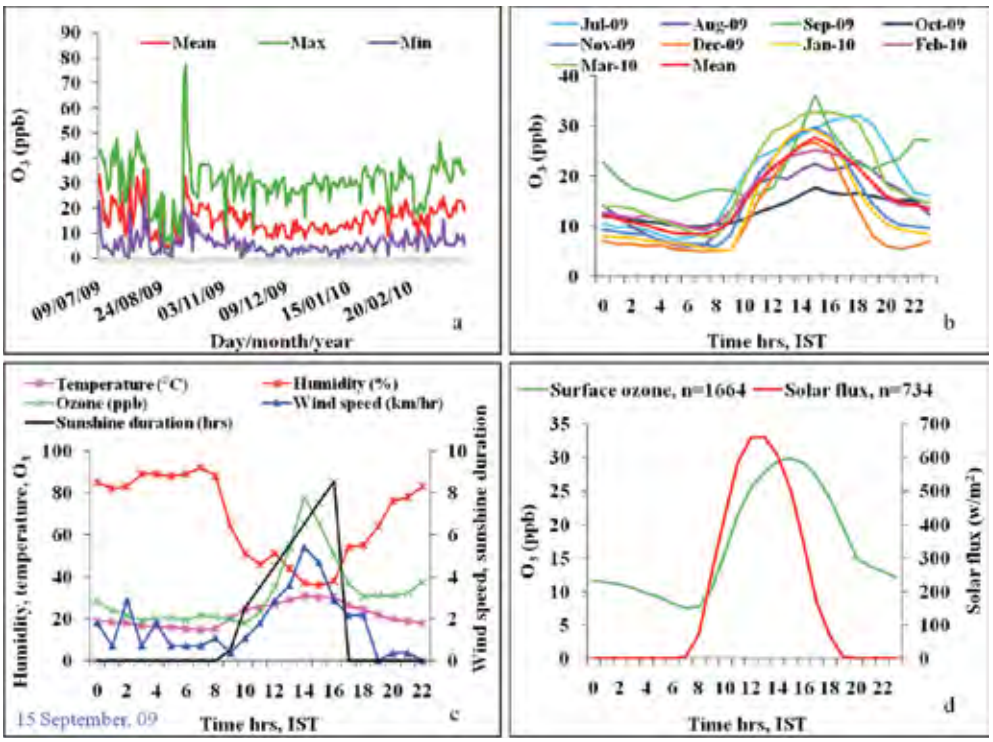



**Fig.44.** Surface ozone concentration: (a) daily, (b) diurnal, and their relation with (c) meteorological parameters and (d) solar flux

**Table-12:** Meteorological parameters during ozone episodes at Mohal-Kullu

| Day | Ozone (ppb) | | Ozone hrs ≥50ppb | Rainfall (mm) | Wind speed (km/hr) | Temperature (°C) | | Humidity (%) | Sunshine (hr) |
|---|---|---|---|---|---|---|---|---|---|
| | Max | Mean | | | | Mean | Max | | |
| 15/09/09 | 77.5 | 32.1 | 4 | nil | 1.7 | 21.6 | 30.9 | 67.3 | 9.2 |
| 14/09/09 | 69.2 | 32.5 | 1 | nil | 1.8 | 21.5 | 29.8 | 71.3 | 9.3 |
| 31/07/09 | 50.1 | 32.4 | 1 | nil | 1.9 | 25.0 | 32.1 | 69.9 | 7.2 |
| 30/04/10 | 50.0 | 26.4 | 1 | nil | 4.3 | 21.7 | 32.7 | 50.0 | 11.0 |

- In addition, surface ozone episodes have been also mainly contributed from external sources through long range transport. The correlation of surface ozone during September 15, 2009 showed strong positive correlation with temperature (r=0.78), wind speed (r=0.78), sunshine duration (r=0.81), solar flux (r=0.8) but strong negative with humidity (r=-0.70) indicating an important role of meteorological parameters to influence the concentration of surface ozone in the region (Fig. 44 c&d).
- When ground based measurements of surface ozone was related with the tropospheric columnar ozone from NASA Goddard Troposphere ozone, its approximate value was observed about 45-50 DU in the month of September. Such columnar ozone also becomes a source of long range transport sources for surface ozone concentrations through air masses in the present study region along with the local sources like vehicular emissions, forest fires, biomass burning and other supportive factors for active photo-oxidation process.

## Ambient air pollution and its sources in the background sites of different hill spots in the northwestern Himalaya, Himachal Pradesh *(2009-2012, DST, New Delhi)*

Ambient air quality includes both- the particulate and gaseous pollutants which varies from one geographic region to another depending on emission sources and meteorological conditions prevailing at a particular experimental location. In the hill spots, increasing tourism activities with high inflow of tourists and their plying vehicles have resulted in atmospheric pollution causing many hazards to human and plant health. Ambient air quality gets deteriorated in summer due to a large number of vehicles as a part of tourism activities in Kullu-Manali,

while it is affected in winter due to biomass burning and forest fires. The major air pollution parameters such as Total Suspended Particulate (TSP) matter, particulate matter below 10 micron ($PM_{10}$), sulphur dioxide ($SO_2$) and nitrogen oxide ($NO_2$) were monitored using Respirable Dust Sampler (RDS-460 NL, FPS APM-550 Envirotech) at two stations; Mohal (1154 m) and Kothi (2478 m). Overall, concentrations of particulate and gaseous pollutants were obtained after exposing 8-hourly samples for a day in the Kullu valley.

## Objectives

- To analyse physio-chemical characteristics of aerosols, gaseous concentration of trace gases and rainwater chemistry in relation to vehicular influx to establish background values in the Himalayan region.
- To observe local meteorological conditions, back trajectories and relate these with the pollution episodes.
- To identify pollution sources from a viewpoint to outline an environment management plan and mitigation strategies to protect the sensitive Himalayan region

## Achievements

- TSP concentration at Kothi showed 218.7±7.6 µg $m^{-3}$ during 8-16 hr IST in July 2009, while at Mohal its concentration was 199.6±9.5 µg $m^{-3}$ during 16-0 hr in April 2009. $PM_{10}$ at Kothi was 53.8±8.4 µg $m^{-3}$ during 8-16 hr in January 2010 and 86.03±7.3 µg $m^{-3}$ at Mohal during 16-0 hr in December 2009. However, $PM_{2.5}$ at Kothi was 99±3.2 µg $m^{-3}$ during 0-8 hr in March 2009 (Fig. 45a).
- Among the gaseous pollutants, maximum $SO_2$ concentration at Kothi was 16.0±1.6 µg $m^{-3}$ during 0-8 hr in May 2009 and 7.7±0.5 µg $m^{-3}$ at Mohal during 0-8 hr in April 2009. $NO_2$ concentration at Kothi showed 5.7±0.7 µg $m^{-3}$ and 5.7±1.0 µg $m^{-3}$ during 0-8 hr and 16-0 hr in April 2009 respectively. But this value at Mohal stood to be 8.2±1.3 µg $m^{-3}$during 16-0 hr in June 2009 (Fig. 45b).
- Incoming plying vehicles based on 12 hourly census (6-18 hr) at Kothi stood to be 2,395 per day in June 2009 as highest. While at Mohal, their numbers due to Kullu Dussehra festival in October 2009 remained as 2,857 per day.
- The meteorological conditions showed the warmest day at Mohal on June 24, 2009 with 38$^0$C and the coldest day on January 1, 2010 with minus 1.5 $^0$C. The average humidity at Mohal throughout the observation period remained 60%. The annual total rainfall at Kothi and Mohal was measured as 1202 mm and 696 mm during April 2009-March 2010.

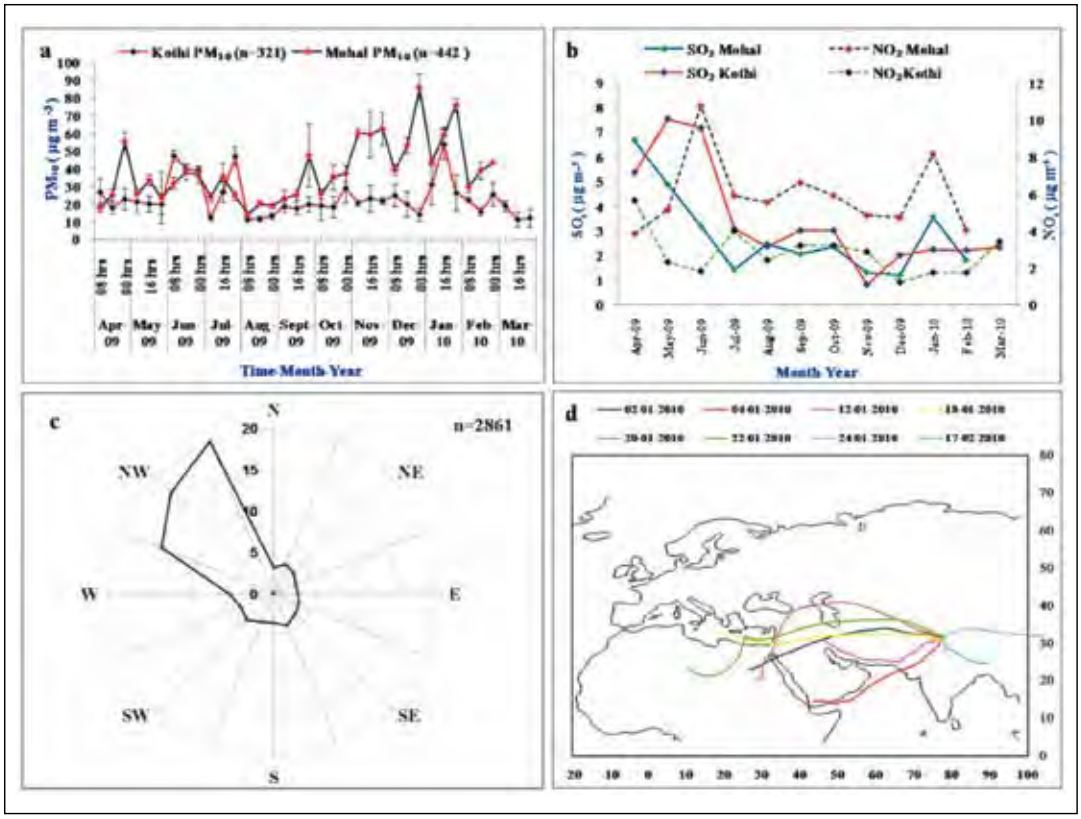



**Fig.45.** Monthly status of (a) $PM_{10}$ (diurnal basis), (b) $SO_2$ and $NO_2$ at Kothi and Mohal, and (c) Wind-rose (%) and (d) back trajectories during episode days of $PM_{10}$ at Mohal during winter season

- The maximum wind speed recorded at Mohal was 25.5 km $hr^{-1}$ on January 5, 2010 at 12 hr. It is found that the winds blow at Mohal mostly from 270-337.5$^0$ (North West direction). The wind rose showed that the relatively high winds blow from 337.5$^0$ direction (Fig. 45c). Back trajectories at Mohal showed that the episode day for mainly $PM_{10}$ was observed during winter season. This air mass came from west direction passing through the dry regions. However, second and third episode days were observed from the east direction (Fig. 45d). The existing meteorological conditions have also played an important role in affecting adversely the particulate as well as gaseous pollutants in the present study region.

## Appraisal of Tourism for Sustainable Management – Case Study of Sikkim Himalaya *(2009-2013, In-house)*

The Himalaya is endowed with the bounty of nature, sacredness and purity of environment. Besides, the religious and cultural diversity is also rich containing further an innate appeal for the growth and development of tourism. Tourism mainly in the Sikkim Himalaya has emerged as a priority sector and its economic potential is being harvested at different levels. However, the limitations of development characterized by complexities of hill topography warrant the sustenance and growth of hill economy. As a result, the existing tourism potential needs to be tapped in a sustainable way. But, the cyclic nature of tourism as manifested in theoretical paradigms and its trade-offs with deteriorating quality of environment, is an inherent threat to its sustainability. Thus, a holistic approach is of utmost importance for sustainability of existing tourism in light of tourist trends, impacts and management; this study of Sikkim is an attempt in this context. Tourism in Sikkim is mainly nature based. The pristine and unspoiled nature, rich biodiversity, panoramic views of snow clad mountains and valleys, monuments and artifacts of Buddhism are the main tourism recreation resources. The state is harvesting cautiously these resources keeping in view of its sustainability. Yet, the tourist inflow patterns, which show a spectacular growth though suggest sanguine prospects, do not augur well in terms of increasing pressure on limited resources, infrastructure, and demand-supply. This calls for an appraisal of management options.

### Objectives

- To study and document nature and process of tourism.
- To assess economic significance of tourism and its impacts.
- To make an appraisal for sustainability of tourism through suggesting management options for policy implications.

### Achievements

- For understanding tourism process, tourists inflow statistics were synthesized and used for analysis of trend-patterns, trend simulations and its demand-supply implications. Fig. 46 depicts the annual, quarterly trend and growth pattern in tourist influx in Sikkim. The tourist influx is continuously increasing with seasonal fluctuations in quarterly inflow, which was almost linear pattern in its initial stage. Annual pattern also exhibits almost continuous growth in tourist inflow suggesting further spurt in future. In the linear mapping of tourist inflow (Y) against time (X) for the periods presented as follow, the comparison of coefficients, also corroborates to this fact and suggests good prospects for tourism enterprises.

  $Y_{1980\text{-}90}$ = 3754.70(X-1979) + 10580.84;

  R-sq = .82, $t_{coefficient}$ = 6.45, p=.0001

  $Y_{1990\text{-}00}$ = 1096.5 (X-1989) + 49259.73;

  R-sq = .89, $t_{coefficient}$ = 8.62, p=.0001

  $Y_{2000\text{-}09}$ = 50193.3(X-1999) + 25237.27;

  R-sq = .85, $t_{coefficient}$ = 6.78, p=.00014

- The monthly statistics of tourists inflow for domestic and foreign tourists for the period 1987 to 2009 is summarized in Table-13. The monthly average influx (domestic cum foreign influx) to Sikkim was 18.52% of the total annual inflow as maximum in May followed by 12.71% in October, 11.99 % in April, 8.77% in November, 8.68 % in June, 7.60% in March, and 7.48% in December. The summer season (April–June) comprised of 39.19% but when this statistics considered from March to June, this influx reached up to 46.79%. The last quarter of the year from October to December showed nearly 28.96% influx of the total annual arrival of tourists. However, two months during winter (January–February), two months in rainy season (July-August) were among the lean tourist months. At contrary to domestic tourists, the monthly foreign tourist influx was recorded 17.26% as maximum in October. However, during fourth quarter (October-December), foreign tourists comprised of 37.83% of the total seasonal inflow.
- The preliminary study regarding negative impacts of tourism reveals these in terms of over construction

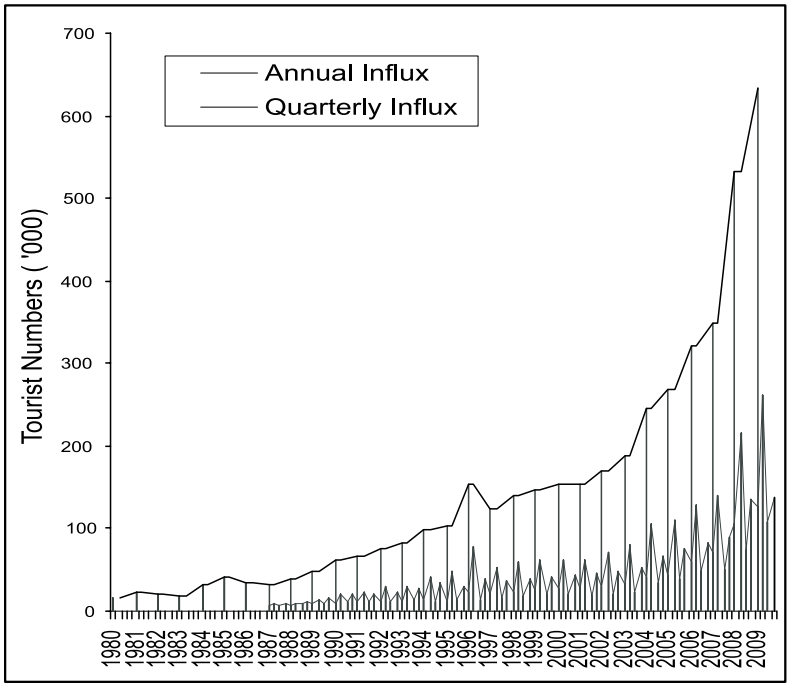



**Fig.46.** Patterns of Tourist Influx in Sikkim, 1980-2009

**Table-13:** Statistics of tourist influx in Sikkim, 1887-2009

| Month | Domestic tourists | | Foreign tourists | | Total tourists | |
|---|---|---|---|---|---|---|
| | Maximum (Minimum) | Per cent of annual influx | Maximum (Minimum) | Per cent of annual influx | Maximum (Minimum) | Per cent of annual influx |
| January | 30395 (1883) | 4.47 | 910 (14) | 4.26 | 31091 (1916) | 4.46 |
| February | 35883 (1971) | 4.79 | 1286 (108) | 6.88 | 36936 (2188) | 4.92 |
| March | 55965 (2054) | 7.34 | 2406 (118) | 11.46 | 58149 (2172) | 7.60 |
| April | 85669 (2254) | 11.80 | 3124 (142) | 14.83 | 88213 (2550) | 11.99 |
| May | 108778 (3492) | 19.18 | 1857 (102) | 7.88 | 110113 (3604) | 18.52 |
| June | 63905 (2144) | 9.03 | 631 (14 ) | 3.26 | 64334 (2181) | 8.68 |
| July | 26992 (2175) | 4.41 | 646 (31) | 2.87 | 27638 (2239) | 4.32 |
| August | 35826 (1612) | 4.43 | 864 (82) | 4.38 | 36672 (1694) | 4.43 |
| September | 41285 (3072) | 6.12 | 1346 (75) | 6.37 | 42560 (3190) | 6.13 |
| October | 49456 (2982) | 12.47 | 3386 (415) | 17.26 | 52842 (3397) | 12.71 |
| November | 43720 (2291) | 8.52 | 2867 (185) | 12.63 | 46126 (2601) | 8.77 |
| December | 42345 (3235) | 7.43 | 1848 (19) | 7.94 | 43736 (3542) | 7.48 |

of settlements, traffic congestion, semi-urbanization of rural areas and changing traditional agricultural food crops, conversion of agricultural land into tourist accommodation and allied purposes, extraction of forest resources, etc. The projections based on current trend for the year 2017 shows a decline in production and supply of indigenously produced products like food grains and livestock population. The continuous increase in tourists and native population will exacerbate these adverse impacts. The food deficit through import would be most plausible substitution under present condition. However, its nutritional implications would also lead to considerable leakage of the state money even from revenue generation from tourism. In certain tourist pockets, this would also result in significant hike in prices of commodities and cost of living.

### Environmental and Social Impacts of Hydropower Projects in Ganga River Basin (between Dharasu and Gangotri) in Uttarakhand *(2009-2010, MoEF, New Delhi)*

India is endowed with rich hydropower potential; it ranks fifth in the world in terms of its existing hydropower potential. However, less than 25% of the total potential is harnessed so far. Hydropower stands therefore one of the major potential energy sources to meet ever increasing demand of the country. Uttarakhand is rich in hydropower potential as it harbours a number of perennial snow fed rivers. Over a dozen of HEPs including both small and

medium size in the upstream from Dharasu to Gangotri in the Bhagirathi valley are either proposed (such as Pala-Maneri), or under construction (such as Loharinag Pala; LNP), or operational (such as Maneri-Bhali Phase I & III : MB-I & MB-II) (Fig. 47). As a result, there has been much public concern about the environmental and socio-economic impacts of these HEPs on this holy river. Consequent upon the directions of the Hon'ble Supreme Court, the construction work of the HEPs in the Bhagirathi river basin was halted in 2008. In this one year pilot study assigned by the MoEF, Govt. of India; a range of stakeholders- the affected villagers due to HEPs and the other interest groups belonging to the above mentioned four major HEPs were consulted with respect to environmental (positive/negative) and socio-economic impacts.

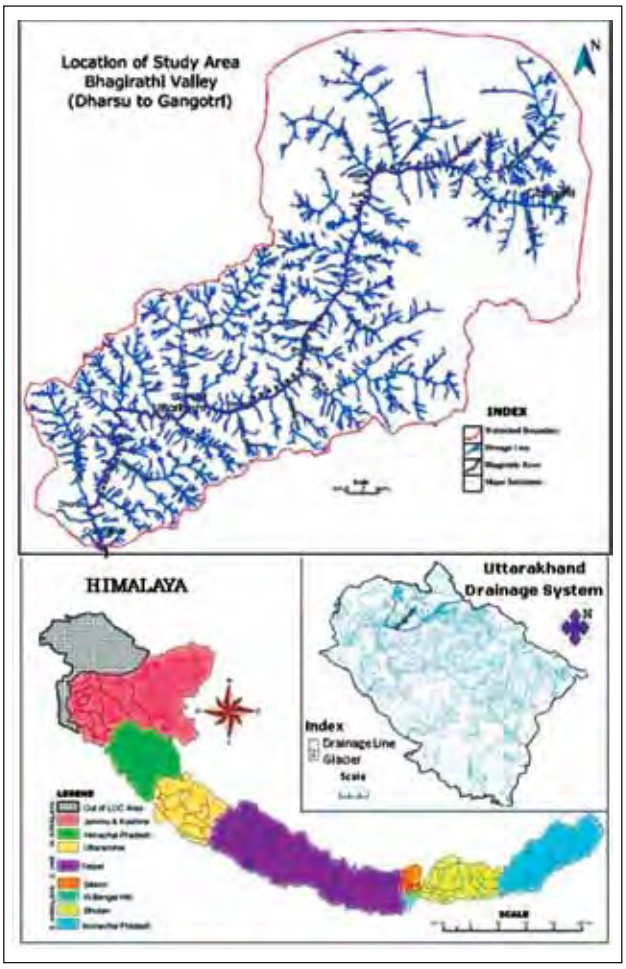



**Fig.47.** Location map of the study area

## Objectives

- To overcome the challenges associated with project level EIA process and try to conduct cumulative impact assessment (-ve/+ve) of various hydropower projects (existing/proposed) on social, biological, and physical environment.
- To suggest the optimal number and the type of hydropower projects such that the development is environmentally viable and socio-culturally acceptable.
- To assess effectiveness of community rehabilitation, employment generation and economic benefits accrued by the local communities through the project activities.
- To make recommendations for the MoEF/State Government or other suitable agencies for modifications or formulation of separate policy/plan.

## Achievements

- During construction work of LNP, 480 villagers got employment in different activities (labourers, office staff, drivers, guards, etc.). Besides the apparent benefits, locals also get indirect benefits such as selling milk and vegetables to the project employees as has been reflected during the survey of LNP, MB-I and MB-II HEPs area. More than 20% of the respondents near MB-I and MB-II HEPs rear more cows/buffaloes due to rise in milk demand.
- Infrastructure development in terms of road network is yet another positive impacts as perceived by the local people. The villagers in the villages like Aungi, Kujan and Tihar in MB-II and LNP HEP region could not sell their farm produce due to high transport cost through ponies. However, some of the villagers now have started to get over this hardship as they are now connected through the roads constructed for HEPs. Road cutting has triggered a series of small to large landslides/landslips in the region. The frequencies of such alteration in landscape are more prominent above the Bhatwari and Gangnani region in the study area, which is geologically most unstable zone.
- The impact on the existing biodiversity of the region was observed in terms of clearing of forest, formation of reservoir, submergence of riparian zone, quarrying of river bed material, choking of vegetation due to muck disposal, loosening the hard rocks due to widening/construction of road, etc. The explosives used in blasting to carve out tunnel also lead to dispersal of wild animals as reported by the local inhabitants. Contrary to this belief, it was observed that birds such as Water Hens, Kingfishers, White-capped Redstart and Plumbeous Redstart were found more abundantly near MB-I and II and reservoir area.
- Drying up of some natural water springs or shift in their outlet points within the vicinity of HEPs was another negative impacts. At some sites, the spring has changed its natural course by approximately 50 m away in instead of dryingsuch as Jamak village of MB-I HEP, and Sighgudi and Pujar villages of MB-II HEP, and

pressure shaft site of LNP HEP. Cracks were also reported by the natives during the study in LNP villages namely Salang, Hurni and Bhangheli. In MB-I, some cracks were also observed near Jamak and Aungi villages.

- Data analysis suggested that peoples' response on impacts varied from one HEP to another. It was also brought out from this study that views of people belonging to the affected villages of the HEPs (operational, under construction and proposed) were somewhat different. It has been perceived by the people that due to capturing the water of the River Ganga into tunnels and reservoirs, pilgrimage- the main source of income in this valley would be affected adversely. However, the likely changes in the trend of pilgrimage / tourist activity due to HEPs are uncertain and indicate further for a detailed investigation.

## Participatory Management of Bhimtal Lake Catchment
*(2005-2010, LDA, Nainital)*

This activity aims to promote strategies and measures for reclamation of degraded community wasteland around the Bhimtal lake and to step up conservation and sustainable utilization of natural resources involving local communities and other stakeholders. To achieve these aims, vegetation and engineering measures were employed in 65 ha degraded community land within Bhimtal lake catchment in two phases. In Phase-I (2005-07), four models (viz. Model I- multi-purpose tree species; Model II- silvi-pasture development; Model III- aromatic plants cultivation and Model IV- agri-horticulture) were developed in 7, 3.5, 5, and 5 ha, respectively in two major villages- Sangurigaon and Songaon in the Bhimtal lake catchment. The Phase-II activities (2007-09) were focused on to replicate the land use models mentioned in Phase –I in the remaining 45 ha community waste land under a participatory approach with the involvement of the local communities of two more villages, viz, Bhaktura and Mahragaon. With these activities, the degraded land will be restored and soil and water conservation measures will save the various life forms in the Bhimtal lake catchment.

### Objectives

- To develop a prototype of land rehabilitation for upgrading management of natural resources in the catchment area.
- To upgrade skill and capacity of stakeholders, particularly farmers and village institutions for sustained peoples' participation.
- To replicate land use models using participatory approach for land rehabilitation and economic upliftment of the rural communities.
- To take up strategic research and documentation activities for strengthening community backups and develop strategies for the conservation and management of the Bhimtal lake catchment and Van Panchayat areas.

### Achievements

- Apart from maintenance and management of the four models during the reporting year, 2718 saplings of different tree species died during the dry season were replaced within the four models developed under Phase-I, in Sangurigan and Songaon Van Panchayats.
- The project activities under the Phase-II in 14 ha degraded land area were taken up in three Van Panchayats (5 ha in Songaon, 5 ha in Bhaktura and 4 ha in Mehragaon) and a total of 1955 tree saplings were planted in Songaon and Mehragaon Van Panchayats. The overall plant survival at the multipurpose tree species model site was 27.4% of the total plantation till March 2009.
- Among the livelihood upgradation activities, three poly houses were erected in two catchment villages which were used for growing saplings of vegetables and off-season vegetables by the beneficiary families.
- Few supporting activities, such as, training and capacity building of self help groups (SHGs) on livelihood options, construction of ploayhouses and rain water harvesting tanks, distribution of fruit trees of improved varieties to the target villages (306 households; 5340 plants), enumeration of local faunal diversity, studies on forest resource use by local communities for fuelwood, fodder and other forest products, land use decision support system development for a few villages, etc. were also carried out.
- Selected women of all the four villages were given hands-on-training to make "Candle, Chalk and Scented sticks" (Fig.48). Besides, one batch of 60 farmers representing mostly women was also trained on low-cost environment friendly and income generating rural technologies, such as, protective cultivation, bio-briquetting, vermi-composting, mushroom cultivation, water harvesting, etc.

**Fig.48.** Community level trainings at Mehragaon, Bhagtura and Songaon for making 'candle, chalk and scented sticks'

## Theme

# SOCIO-ECONOMIC DEVELOPMENT (SED)

The Indian Himalayan region (IHR) is a unique zone of convergence harbouring diverse cultures of plethora of ethnic communities. Bio-physically, this ecosystem is very rich. However, the ability of this mountain ecosystem is fast approaching many of its limits and the ecosystem is gradually becoming unable to provide a minimum standard of living to its continually growing population, therefore, inducing poverty. The continued population growth and consequential poverty are fast depleting the finite natural resource base and breaking down the indigenously evolved resource use patterns that were socially sanctioned and culturally patterned. Therefore, reduction in poverty in this ecosystem through appropriate interventions and skill enhancement of the local communities for rational and judicious use of local resources for their social and economic development is crucial as decrease in poverty can increase in environmental protection.

With this in view, the Socio Economic Development Theme has focused on identified activities such as innovative livelihood options, sustainable tourism, entrepreneurship and self employment, indigenous knowledge, and migration and its socio-economic and cultural implications, which have potential to benefit the economically disadvantaged communities of the IHR reversing the trend of poverty. In the process, the Theme has also emphasized on identification and implementation of region specific sub-activities such as strategy for economic development of small holders farming systems, scaling of innovative resources management practices by communities themselves, assessment of ecotourism potential, documentation of local health traditions, capacity building for entrepreneurship development, technology development, dissemination and backstopping, managing shifting agriculture focusing on enhancement of fallow period, participatory assessment of sustainable scenarios for Himalayan pastoralism, and culture in conservation and sustainable development and many others.

The theme envisages to i) develop resource planning and management strategies based on sound ecological, economic and cultural database and policy analysis, ii) strengthen livelihood promotion strategies (on- and off-farm) through identification of innovative livelihood options, strengthening indigenous livelihood practices and value addition, technology backstopping, and capacity enhancement, iii) minimize negative natural resource use effects by adopting/adapting/replicating best-management practices to see the efficacy of various developmental and R&D interventions for policy implications, and iv) develop 'Rural Enterprise Services' for socio-economic upliftment of Himalayan communities. The main objectives of the theme are: (i) Sustainable tourism; (ii) Entrepreneurship and self employment in the Himalaya; (iii) Indigenous knowledge: traditional lifestyle, architecture and healthcare practices; and (iv) Migration: socio-economic and cultural implications

### Smallholder Farming Systems: Strategies for Economic and Environmental Viability in the Western Himalaya

*(2007-2012, In-house)*

The small farm is an integral part of the agroecosystem in the IHR where 60-80% families comprised of <1 ha landholdings. Moreover, most of the crop farming in the region is rainfed and is characterized by tiny and sloping terraces which in return produce very low yield. The farm yield is far less than to meet the adequate dietary demand of the small landholding farmers. Working with smallholders therefore form an important priority area for the IHR. Simultaneously, handling the issues like degradation of arable land, diversification of rural income and rehabilitation of common property resources with respect to farmers' aspirations and constraints would help a lot in improving the status of these farmers. The development pathway could become possible only when need based intensification approach according to the small farmers be put forward. Increasing community access, participation in natural resource management and diversifying livelihood options at village level would be the primary steps in this regard.

## Objectives

- To undertake in-depth assessment of farming systems and its economic growth in the western Himalayan region.
- To identify issues and options for rural income diversification (on farm and off-farm).
- To restore the common as well as degraded areas in the villages.
- To strengthen village energy and fodder requirements, and plantation of commercial species.
- To strengthen village institutions for natural resource management, and
- To develop pathways and policies for rural livelihood options.

## Achievements

- A representative village- Patharkot in district Almora for on-farm activity for rural income diversification was selected. Keeping in mind to develop a horticultural model, 5.9 ha culturable community wasteland was developed through planting 2920 fruit plants of different varieties. After two years in March 2010, the survival of this plantation was found to be 55%. In view of replacing this mortality, 790 saplings of different varieties of fruit plants during the reporting period 2009-10, were again planted. Then this survival was recorded 73% in March 2010 (Table-14).
- The shortage of fuelwood and fodder was estimated as 207 MT and 120 MT respectively. With a view to improve this situation, plantation with 3680 saplings of different fuelwood and fodder species was done on 5.2 ha of degraded community wasteland.
- Standing biomass value of a community managed Oak (*Q. leucotrichophora*) dominated forest in this village was estimated 341.47 t/ha. This was within the upper range (245.0-387.6 t/ha) of the biomass values when compared with the reported ones for less disturbed natural Oak forests of this region.
- Studies on 10 community managed forests in the region to examine the structural and functional attributes and community management practices indicated that the Oak dominated forests are in better condition than the Pine and Oak-Pine mixed forests. A significant association was found between forest density and use value of the forest (p=0.00), forest condition and level of enforcement through rules (p=0.00), and between forest condition and leadership quality of the village headman (*Sarpanch*) (p=0.00).
- In Sawar village (Chamoli district), a community managed Oak dominated forest (area=137 ha) revealed that the village people have developed a village level institution '*Rakha committee*' (locally *Rakha* means to protect). This committee enforces strict rules and regulation for the management and resource use pattern of this forest. Phytosociological analysis of this forest reveals that higher number of individuals were high girth class structure and higher number of young individuals are indicators of the sustainable condition of this forest (Fig. 49).

**Table-14:** Fruit tree plantation in Patharkot village

| Vernacular name | Scientific name/ varieties | No. of planted saplings (monsoon 2009 & winter 2010) | % survival (as per census held in March 2010) | Average height (cm) (March 2010) |
|---|---|---|---|---|
| Guava (Variety 1) | *Psidium guajava* | 50 | 64.00 | 49.9±9.2 |
| (Variety 2) | | 50 | 56.00 | 48.2±13.6 |
| (Variety 2) | | 50 | 46.00 | 44.1±6.6 |
| Amla (Variety 1) | *Phyllanthus embilica* | 50 | 50.00 | 45.5±9.9 |
| (Variety 2) | | 50 | 62.00 | 53.4±18.8 |
| Lemon (Variety 1) | *Citrus limon* | 100 | 63.00 | 44.5±9.5 |
| (Variety 2) | *Citrus aurantifolia* | 100 | 65.00 | 36.0±8.8 |
| Mango | *Mangifera indica* | 20 | 40.00 | 59.2±29.0 |
| Peach | *Prunus persica* | 30* | 60.00 | 46.9±15.9 |
| Pear | *Pyrus communis* | 20* | 45.00 | 52.08±13.9 |
| Apricot | *Prunus armeniaca* | 20* | 55.00 | 62.0±15.6 |
| Apple | *Pyrus malus* | 50* | 38.00 | 56.0±8.8 |
| Chakotra | *Citrus spp.* | 200* | 68.00 | 66.0±18.8 |
| **Total** | | **790** | **73.29** | |

*Planted in winter (January) 2010, while remaining species were planted during monsoon (July-August) 2009

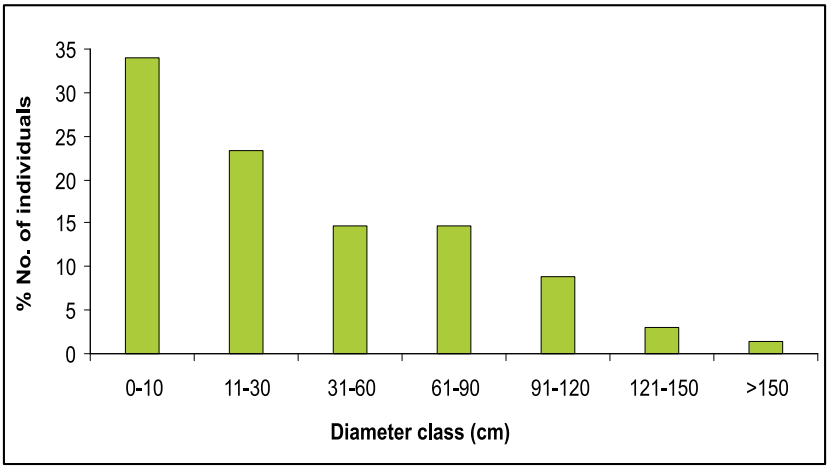



**Fig.49.** Girth class structure of the community forest in Chamoli district

## Shifting Agriculture: Issues and options with focus on adaptive interventions to make it ecologically, economically and socially viable *(2007-2012, In-house)*

Shifting agriculture is practiced in 21 states covering about 22.78 lakh ha of land and 6,07,536 families in India. The importance of this farming system, commonly known as jhum, in NE India could be realized from the fact that it continues to be a predominant land use system and livelihood option covering about 3.87 lakh ha of land and 4.43 lakh families. However in the NE India, shifting agriculture, which was once considered to be an efficient system of cultivation being sustainable both ecologically and economically, is gradually becoming untenable under pressure from a number of factors and besieged with conflicting views in regard to the degradation/ conservation of ecosystem and the way of life of the upland people. Irrespective of the conflicts, shifting agriculture, which is a well knitted assemblage of socio-cultural and economic traits, continues to be the predominant land use system and primary livelihood option of the majority of the communities of NE India. In managing the shifting agriculture, the tribal communities of the NE region, over the period, have accumulated a rich and time tested traditional ecological knowledge (TEK). Documentation of this TEK, which is fast disappearing adversely impacting the unique resource ownership and utilization pattern of shifting agriculture, has assumed high priority. Further, the lack of baseline information on biological data prevents reliable evaluation of biodiversity values of shifting agriculture, seriously hindering effective approaches for conservation of faunal diversity. Keeping these in view, the project aims to review both customary laws and state policies on shifting agriculture for their possible synchronization, introduce potential low cost technologies for improving shifting agriculture, validate indigenous soil and water conservation practices and analyze the impact of shifting agriculture on faunal diversity in Arunachal Pradesh with recommendations to make the system ecologically, socially and economically viable.

### Objectives

- To review the state and central policies and laws in the forest and agriculture sectors dealing with shifting cultivation and ongoing schemes and programmes of state and central Government for control and regulation of shifting cultivation.
- To study the land tenure and customary laws of selected ethnic communities relating to shifting cultivation.
- Documentation of TEK on soil conservation, water & forest resource management and validation of indigenous soil & water conservation practices.
- Impact of shifting agriculture on faunal diversity with special reference to avifauna and mammals.
- Need based assessment and identification of potential interventions and their application.

### Achievements

- The project site covers twenty-five villages in five districts of State of Arunachal Pradesh – East Siang, West Siang, Upper Siang, Papumpare and West Kameng. Three major tribal communities, i.e., Adis, Nyshis and Sherdukpens are studied on the basis of their extent of dependence on shifting agriculture and various projects and schemes implemented by development organizations, particularly line departments of the state.
- During the reporting period two major programmes, i.e., Nagaland Environment Protection and Economic Development (NEPED) and North Eastern

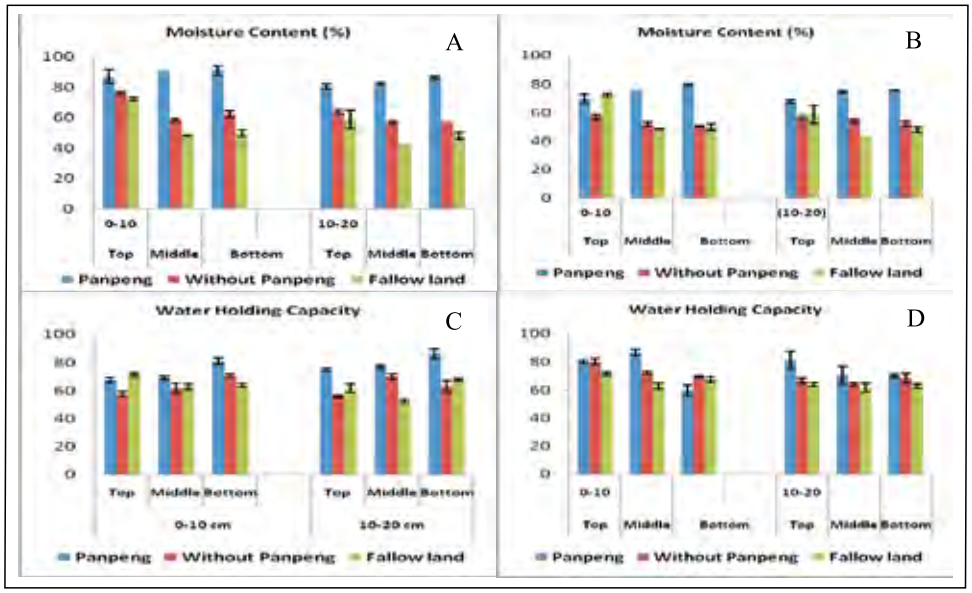
Region Community Resource Management Project (NERCRMP) and five Acts, i.e., (1). Balipara/Sadiya/ Tirap Frontier Tract Jhum Regulation Act, 1947, (2). Arunachal Pradesh Anchal Forest Reserve Act, 1975, (3). Arunachal Pradesh Forest (Removal of Timber) Regulation Act, 1983, (4). Assam Forest Regulation, 1891, and (5). Forest (conservation) Act, 1980 relating to shifting agriculture were reviewed (Table-15).

- Preliminary physico-chemical analyses of two indigenous soil and water conservation (ISWC) practices, i.e., *Panpeng* of Adi community and *Phai* of Nyshi community revealed that shifting agricultural fields with ISWC showed positive trends of maintaining soil fertility in comparison to shifting agricultural fields without indigenous soil and water conservation (WISWC). Soil textural class analysis in the process of validation of the *Panpeng* revealed the presence of higher proportion of sand particle in the field WISWC practice than the fields with ISWC practice establishing that *Panpeng* is more effective in checking erosion and surface runoff. Further, positive trends of soil moisture content and water-holding were revealed in shifting agricultural fields with *panpeng* in comparison to shifting agricultural fields without *Panpeng* (Fig. 50 & 51).

- A total of 20, 21 and 28 tree species were recorded from 10-year old, 25-year old and 50- year old fallows using Principal Centered Quadrates method. Two pioneer species (*Eurya acuminata* and *Sauraia nepalensis*) dominated in young fallows while mature forest species like *Castanopsis* spp were abundant in matured fallows. A total of 84 species of birds were recorded from the landscape. Studies revealed that fallows closer to human settlements supported relatively fewer species than fallows located farther from the village.

**Table-15:** Salient features of review of Balipara/Sadiya/Tirap Frontier Tract Jhum Regulation Act, 1947

| Positive aspects | Negative aspects |
|---|---|
| i) As per this act the customary rights of the cultivation are given more priority for those who are permanent inhabitants of the area. | i) In this Act, in the permanent or semi-permanent cultivated land whether irrigated or not, permanent cultivation is not permitted. Permanent cultivation is subjected to the approval of the Deputy commissioner. |
| ii) It gives rights to cultivate by means of shifting cultivation or utilise by clearing jungle or for grazing live-stock. | ii) It restricts the transfer of land to another community or to any individual without the permission of the land conservator (who is a government official). |
| iii) The Act permitted to utilise the forest produce that are having customary right over the land. | iii) The utilization of forest produce is bounded by other rules and regulations in force determining or relating the sale of such produce. |
| iv) The government has rights to use the jhum lands for public purposes with proper notification and compensation. | iv) The compensation is not up to expectation of the people. |




A. Soil moisture content before slashing; B. Soil moisture content after burning;
C. Water holding capacity of soil before slashing; D. Water holding capacity of soil after burning

**Fig.50. Soil moisture content and water holding capacity analyses for validation of the** *Panpeng*

**Fig.51. *Panpeng*, an indigenous soil and water conservation practice, in shifting agricultural fields**

## Scaling up innovative resource management practices for improved livelihoods in the mid hills of the central Himalaya *(2007-2012, In-house)*

The mountains of the Himalaya, which vitally contribute to the ecological sustainability of the region are threatened by increasing population, open grazing, soil/nutrient erosion, deforestation, and overall losses of biodiversity. Probably, the follow up of the efforts made under different activities aiming to address these problems, was not well planned and as a result, such efforts were not able to halt the process of degradation of the resources. Building on the lessons learned from different studies and innovations tested for improved livelihood of the people, technical back stopping and material support is needed to be provided to the villagers, particularly to the marginal farmers in the adoption/adaptation process. The present study aims to follow the adoption/adaptation process and scenario of the tested options/ innovations and facilitate for improved management of the natural resources through up scaling farm based interventions, strengthening market linkages, soil and water conservation, rehabilitation of community degraded lands, strengthening of weakened farming system concept, etc., in Garurganga watershed of Bageshwar district.

### Objectives

- To analyze adoption/adaptation scenario of tested/ innovative resource management practices.
- To develop strategies for adoption/adaptation of innovations for improved economic and ecological viability in the region.
- Scaling up of the viable practices through participatory action research involving community institutions, local stakeholders and resource farmers.
- Sharing of knowledge and information through improved networking of the stakeholders by organizing regular meetings/workshops and exchange visits.

### Achievements

- Stakeholder consultation followed by base line survey for adoption/adaptation (Table-16) of different options of improved livelihoods and management and conservation of natural resources during last 15 years has been completed in 43 villages covering 354 households.
- Preliminary results (Table-17) revealed that the farming system, as a whole, is under stress due to scarcity of water, sectoral approach of the developmental activities, weak backstopping, and unstructured monitoring and evaluation system. In fact, overall improvement on livelihoods of the people during the period has been realized by the stakeholders; however, the scenario had also impacted adversely on status of the natural resources and overall farming system of this region.
- The deteriorating state of the natural resources has been observed, particularly in traditional agriculture, which is either in a process of transformation to cash crop (if water is available) or 'no agriculture' due to a number of reasons. Adoption scenario clearly indicates that the farmer is a selective taker and adopt a very few, out of a long list of options.
- Due to the ownership issues and limited monetary resources, most of the Van Panchayats are non-functional and as a result, waste land/community land rehabilitation is not in the list of people's priority. Like wise, introduction of hybrid livestock merely helped in improving livelihoods due to non-favouring climatic conditions, improper management and quality of feed.

**Table-16:** On-farm livelihood options: Adoption/Adaptation during the reporting period

| Major Livelihood options | Demonstrations | Adoption/Adaptation | |
|---|---|---|---|
| | | Villages | No. of house holds |
| Off season vegetable cultivation | - | 04 | 14 |
| Improved grasses | - | 09 | 26 |
| Integrated fish farming | - | 05 | 11 |
| Water harvesting & storage | 2 | 05 | 08 |
| Soil/water conservation | 2 | 03 | 05 |
| Farmer's nursery | - | 02 | 02 |
| Composting | 2 | 06 | 14 |
| Cash crop cultivation | Facilitation | 05 | 10 |
| Horticulture | Facilitation | 03 | 07 |

**Table-17:** Preliminary results revealing probable factors promoting/limiting adoption of options

| Options | Adoption | Probable causes |
|---|---|---|
| Soil/water conservation | Slow adoption | Low productivity of the upland farming is major limiting factor; also engineering structures are economically less viable. |
| Water harvesting & storage | Not significant | Possibilities of utilization of stored water in agriculture are limited due to fragmented land holdings. |
| Fish culture (value addition to the water harvesting) | Adoption rate is high | Ensured immediate economic benefit without additional workload. Demand is very high compared to production. However, water is often a limiting factor. |
| Green fodder/winter fodder | Adoption rate is high | In-adequate availability of green fodder for livestock, which is an integral part of the farming system, is the factor for higher rate of adoption of fodder. |
| Cash crop cultivation | Significant | Low volume- high value option and ensured short-term benefits are promoting factors. |
| Protected cultivation | Significant | Ensured short term benefits and availability of market are promoting factors; however, non-availability of quality seeds and water could be the limiting factors. |

- Up scaling of options, knowledge dissemination, conservation and storage of water linked with fish culture, protected cultivation, etc., have already been initiated with small land holders, which need to be continued with regular backstopping and material support.

### Institutionalizing technology backstopping and capacity enhancement for sustainable agricultural development and encouraging entrepreneurship development based on simple rural technologies within the tribal areas of North East India *(2006-2010, Department of Science and Technology, Govt. of India, New Delhi)*

Agricultural development in the uplands of the NE India to be sustainable requires a concerted technology backstopping, as access to technology in the region is grossly inadequate, given the constraints of terrain and the limits of concerned line departments. This necessitates for a decentralized technology backstopping system through capacity building, demonstration and dissemination of technologies in NE states. Keeping this in view, upscaling of technology dissemination is carried out through seven partner NGOs (PNGOs), who have selected relevant technologies, appropriate to the needs of the farmers of their respective areas and established technology demonstration parks, preferably on their own land, so that such parks become a permanent technology demonstration and dissemination centre for the relevant state/district. The North East Unit of the Institute is the Coordinating Agency for technology development, up-gradation, modification, demonstration and capacity building. The PNGOs have been demonstrating, disseminating identified technologies purposely selected through survey and PRA exercises. The mechanism has also been utilized for feedback to facilitate technology up-gradations and for prioritizing location-specific technology needs at the grassroots so that appropriate technologies addressing the needs are developed and grassroot issues are incorporated in research agenda. The project is focusing on the tribal population of North East India. The tribes included are Boros, Hmar and Biete of Assam; Mao Nagas and Tangkhul Naga tribes of Manipur; Mizos of Mizoram; and Garos, Reangs, Debbarmas and Darlongs (Kukis) of

Tripura and Jiantias of Meghalaya. Agriculture practice in these areas is predominantly shifting agriculture or Jhum barring the Boro dominated areas in Assam where they practice settled cultivation. Terrace cultivation is also a common practice in Manipur. The tribes are mostly agriculturists in occupation.

## Objectives

- To institutionalize a process mechanism for technology backstopping and capacity building of rural upland farmers in simple, low-cost, appropriate technologies through a network of credible NGOs.
- To hand-hold and build up the capacity of selected partner NGOs (PNGOs) to set up Demonstration Centres and On-farm demonstrations and facilitate a process mechanism for capacity enhancement of upland tribal farmers, particularly shifting cultivators.
- To facilitate a process mechanism for identifying technology input needs in remote marginalized areas and built a community-driven process mechanism for addressing technology gaps.
- To establish a process mechanism for capacity building in On-Farm technologies and enhance technology dissemination through On-Farm demonstration and trainings.
- To technically validate technology modifications/ adaptations for further technology up-gradations.
- To develop technology dissemination material (ICT-printed, audio-visual and other material) and ensure wider dissemination in local languages through Partner NGOs.
- To encourage entrepreneurship development among rural youth, especially women, based on simple low cost, appropriate technologies.

## Achievements

- Up scaling of technology backstopping is carried out in the North Eastern region with the help of seven PNGOs through establishment of seventeen Demonstration Centres and about thirty-three On-farm demonstration sites in twelve Development Blocks spread over eight districts in five states (Fig. 52 a, b & c). During the reporting year, as many as 970 farmers from 49 villages and more than 11 tribal communities were given training for their capacity building by the PNGOs on 12 technologies (Table-18).
- The PNGOs have selected technologies based on the specific need of their region for agriculture and entrepreneurship development. For example IIRM-Assam has selected and adopted 10 technologies, CEP-Mizoram 7 technologies, NAMRHEN-Meghalaya 9 technologies, NIDA - Manipur 7 technologies, SSRD - Manipur 12 technologies, NCHHCO-Assam 10 technologies and St. VWS-Tripura has selected 10 technologies.
- Six technologies, i.e., weed composting, vermi-composting, bio-briquetting, haandi system of irrigation, zero energy cool chamber or their use pattern are being modified by the NGOS/farmers without altering the basic principles of the technologies based on local relevance and scope for entrepreneurship development. For example, the haandi system is applied with a model of Drip Irrigation using bamboo and also the traditional earthen pot used in haandi technology is replaced by plastic containers/bottles.
- To ensure sustained community participation, some PNGOs have formed SHGs and cooperatives like farmers club. As many as 69 SHGs and 3 Farmers Club, 1 Marketing Committee are formed by the PNGOs and number of entrepreneurships are developed. To cite an example, Centre for Environment protection (CEP), Mizoram has formed 25 Self-Help Groups (SHGs) in its project area with the help of NABARD to boost up enterprise development and for strengthening the capacity of stakeholders. SHGs are encouraged to make savings first instead of availing micro-credit facility based on the principle *"savings first – credit later"*.

**Table-18:** Farmers trained during 2009-10 by the PNGOs across the NE States

| Sl. No. | Name of PNGOs | Peoples participation/coverage | | | No. of Farmers trained | | |
|---|---|---|---|---|---|---|---|
| | | Districts | No of villages covered | Communities covered | Male | Female | Total |
| 1. | IIRM, Assam | Sonitpur | 10 | Boro | 80 | 40 | 120 |
| 2. | CEP, Mizoram | Aizawl, Kolasib | 5 | Mizo | 60 | 55 | 115 |
| 3. | SSRD, Manipur | Ukhrul | 5 | Tangkhuls | 62 | 105 | 167 |
| 4. | NIDA, Manipur | Senapati | 6 | Mao Naga/ Liangmei Naga | 40 | 80 | 120 |
| 5. | St. VWS, Tripura | Dhalai | 10 | Garos, Reangs, Debbarmas, Darlongs (Kukis) | 107 | 163 | 270 |
| 6. | NAM-RHEN, Meghalaya | Jaintia Hills | 8 | Jaintias | 49 | 64 | 113 |
| 7. | NCHHCO, NC Hills, Assam | NC Hills | 5 | Hmar, Biete | 30 | 35 | 65 |
| Total | | 8 Districts | 49 | 11 Communities | 428 | 542 | 970 |

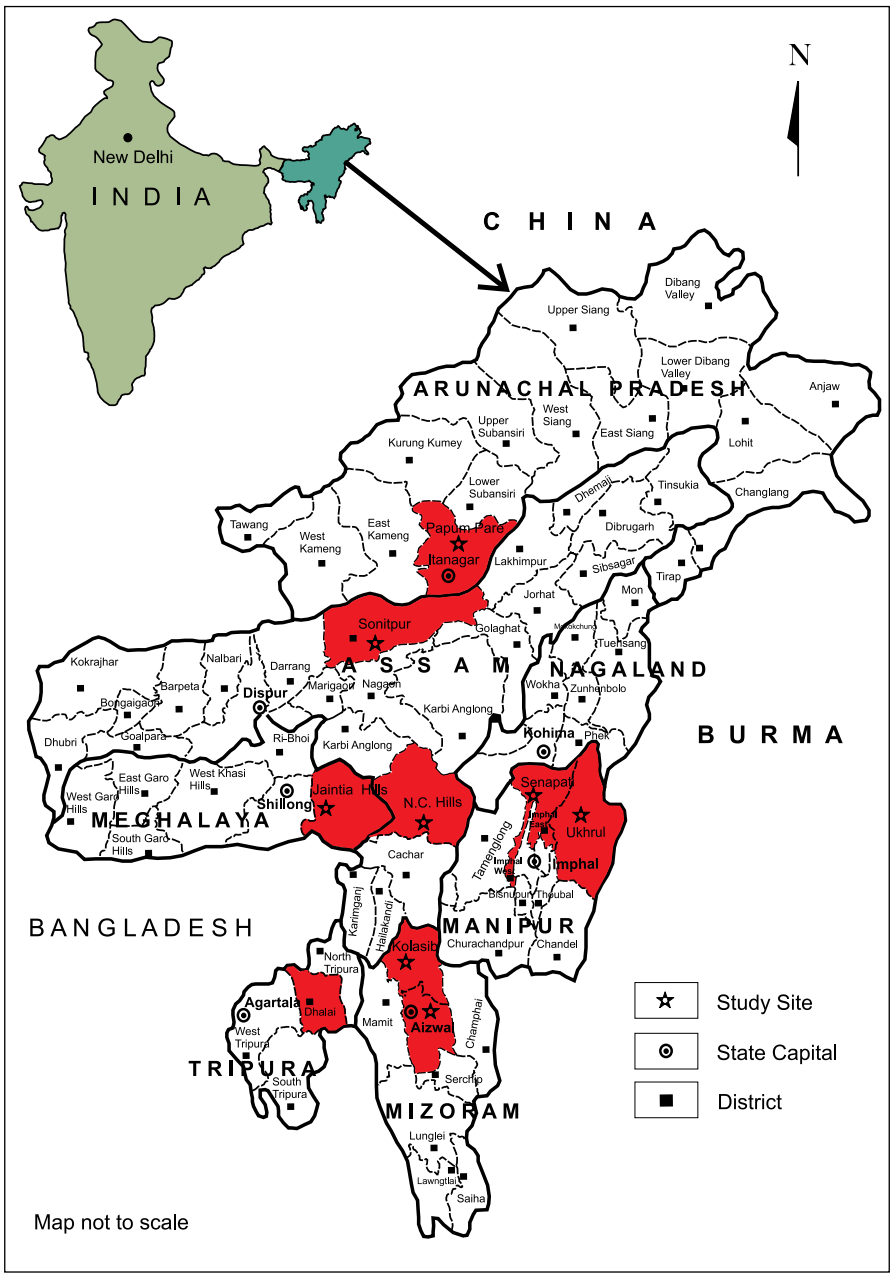



**Fig.52 (a).** Map of the project sites across NE India

**Fig.52 (b).** Modified haandi technology in Meghalaya

**Fig.52 (c).** Modified Haandi (drip irrigation) technology using bamboo in Manipur

- Couple of technologies like vermi-composting, bio-briquetting, weed-composting are taken up by farmers towards entrepreneurship development. In the project villages of Society for Sustainable Rural Development (SSRD) in Manipur by using bio-composting and vermi-composting in their farms, particularly in mixed cropping system, farmers enhanced crop yield, which is being sold in the market ensuring cash generation. They could earn an additional income of about Rs. 10,000 per annum from mix cropping in the home gardens.

### Biodiversity Conservation through Community based Natural Resource Management in Arunachal Pradesh (GOI-UNDP-CCF-II Project *(2008-2012, GOI-UNDP CCF-II)*

Arunachal Pradesh is India's biological frontier; arguably the biologically richest region in the country. Located in the Eastern Himalayan biodiversity hotspot, it is one among the 200 globally important eco-regions. It has also been designated as a globally important Endemic Bird Area as out of the 1200 bird species in India, nearly 600 have been recorded from Arunachal. Culturally, it is also quite rich being home to 26 major and 110 minor indigenous communities. However, the rich bioresource of the state, particularly its fauna, is being seriously threatened in the recent time under various forces. Therefore, an effort has been made with this project to conserve the rich biodiversity of the state, through community participation and adopting an integrated approach embracing to the acknowledged fact that biodiversity conservation approaches do not work in isolation of traditional communities inhabiting along the forest fringes. The project focuses on local human resource development and a mechanism to institutionalize the process of environmental sustainability through formation of community based institutions and their involvement in the entire process of interventions for biodiversity conservation and livelihood development. The project basically aims at developing viable, replicable and effective community based natural resource management initiative in the proposed Tawang-West Kameng Biosphere Reserve (TWKBR) and Apatani Plateau in Lower Subansiri District of Arunachal Pradesh by providing incentives to the local communities to effectively conserve and enhance biodiversity.

#### Objectives

- To promote participation of local communities in biodiversity conservation measures and resource management.
- To promote alternative livelihood schemes like ecotourism, agro forestry, and micro enterprise in the project areas to provide incentives and reduce natural resource dependence.
- To improve upon shifting cultivation and promote of livelihoods through technological interventions.
- To enhance community well being (Primary health care and education).
- To carry out studies and inventories about the lack of information for improving policies, knowledge base and monitoring.

#### Achievements

- Twenty two (22) Biodiversity Management Committees (BMCs) formerly known as Village Biodiversity Conservation Councils (VBCCs) have been constituted across the project sites for conserving and sustainably managing the bioresources in project villages.
- Nearly 5000 hectares of *Mihin-Radhe* community forest in Apatani plateau have been brought under Community Conserve Area (CCA). *Tajang Rantee Sacred Grove*, a forest patch of three villages (Moilyang, Lempia and Tajang) in Apatani plateau has been strengthened.
- Three high altitude nurseries have been developed for propagation of *Taxus wallichiana, Swertia chirayata* and multi-purpose tree species. Approximately 30,000 *Taxus wallichiana* saplings have been propagated in the High Altitude Nursery at Ziro Plateau. Plantation of horticultural crops have been initiated by bringing 6.25 and 8.55 ha of land area under kiwi (*Actinidia deliciosa* ) and large cardamom (*Amomum subulatum)* plantation, respectively.
- Income generation activities (IGAs) are carried out by providing piglets to 60 families in phase I and 40 farmers from project villages were given hands-on-training on 15 different low-cost rural technologies for capacity building and development of entrepreneurship skill.
- Bioresources inventorisation and dependency assessment have also been carried out in project sites, which revealed wide range of importance of bioresaources for the communities ranging from food values to social and economic values (Fig. 53 a, b. & c).

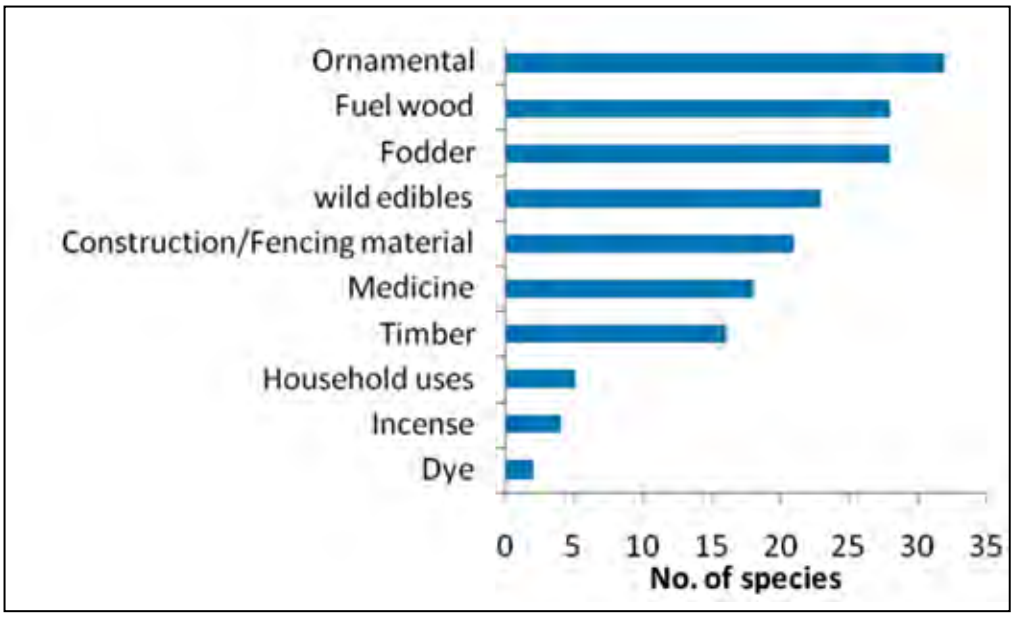



**Fig.53 (a).** Use value of floral species documented from TWKBR.

**Fig.53. (b)** Awareness campaign on biodiversity conservation and resource management in project site-I (TWKBR)

**Fig.53. (c)** Awareness campaign on biodiversity conservation and resource management in project site –II (Apatani plateau)



## Cultural landscape: the basis for linking biodiversity conservation with sustainable development of Arunachal Pradesh, India *(2008-2011, UNESCO-McArthur Foundation, New Delhi)*

Cultural landscapes are complex socioeconomic expressions of ecosystems that have co-evolved under the influence of biophysical factors as well as of human societies at different levels of their cultural, social, and technological development. Human cultures have always been influenced and shaped by the nature of the ecosystem. At the same time, humankind has always influenced and shaped its environment to enhance the availability of certain valued services. Precisely, cultural manifestation in an ecosystem could simply be understood from the very definition of culture that it is that complex ,which include art, belief, knowledge, morals of any other things acquired by the man as the member of the society. Therefore, the way of life, i.e., culture, of the traditional communities living near to bioresources must be comprehensively understood and be integrated in biodiversity conservation strategies for effective conservation and sustainable development; however, the relationships between culture and biodiversity are complex, which need extensive investigation. Keeping this in view, the study aims to address biodiversity conservation with concern for sustainable development of traditional communities living in the mega cultural landscape along an altitudinal transect of the Tawang and West Kameng districts in Arunachal Pradesh, inhabited by Monpa and Sherdukpen tribal communities alongwith others like Mijis (Sajolang), Bugun and Aka. Two minor tribal communities Lishpa and Chugpa also inhabit the region.

### Objectives

- Landscape system analysis, figuring out the linkages between natural and human-managed ecosystems

in the landscape and the manner in which they are linked to the village ecosystem functioning.

- Trying to evaluate the manner in which traditional societies perceive management of biomass, soil fertility and water resources within the landscape and the kind of eco-cultural drivers that ensure effective management of natural resources, and it's sharing on an equitable basis.
- A detail analysis of the culture-based non-codified institutional arrangements, such as the organisation of cultural calendar linked to the biophysical dimensions of the ecosystems that they are concern with.
- Issues related to competition vs coexistence of different ethnic groups within and outside the identified boundaries of a given cultural landscape and their implications for sustainable use of natural resources within and between societies, and
- The role of institutional arrangements for effective management of natural resources with emphasis upon the traditional institutional arrangements.

## Achievements

- Role of religious institutions like Gompa (Monastery) in conservation of species (Table-19) and deities enhancing to conservation that are being worshiped or believed by Monpas and Sherdukpens, respectively, have been recorded. A total of 24 plant species were identified, which were being ranked higher in cultural and traditional belief system of Sherdukpens society and most of these plants are conserved due to their religious, economic and medicinal values.
- The social and cultural values associated with four higher altitude lake complexes viz. Bangajan Wetland Complex, Nagula Wetland Complex, Pangchen Lumpo Muchat Wetland Complex and Thembang Bapu Wetland Complex existing in this cultural landscape have been documented (Fig.54).

**Fig.54.** Flags across water sources for protection of the source (a Monpa religious practice)

- The cultural calendars corresponding to the agricultural calendars of the Monpa and Sherdukpen communities (Table-20) were documented along with the various belief systems, rituals, traditional dances, food items and food habits and art & crafts involving festivals. Number of ethnic food items viz. *Hu jyo, Bokpi, Thukpa, Momo, Loco Momo, Khapse, Chukchro* and *Churpi* and indigenous alcoholic beverages viz. *Nodok Phok, Bukku Phok, Gacham Phok, Ningri* and *Ara* of the Sherdukpen community were also documented.

**Table-19**: Trees conserved/planted in the surrounding area of the Gompa (Monastery)

| Sl.No. | Botanical Name | Local name | Uses |
|---|---|---|---|
| 1. | *Cupressus cashmeriana* | Poss sing | Incense |
| 2. | *Cupressus torul osa* | Wangsing | Incense |
| 3. | *Thuja orientalis* | Wangmu | Incense |
| 4. | *Pinus roxburghii* | Bechi hing | Incense |
| 5. | *Pinus wallichiana* | Lenchong hing | Incense |
| 6. | *Cryptomeria japonica* | Urgling shing | Incense |
| 7. | *Eucalyptus sp* | Eucalyptus | Incense |
| 8. | *Juniperus sp.* | Shukpa | Incense, wood & leaves for rituals |

**Table-20: Cultural calendar corresponding to agricultural calendar of Sherdukpen tribe**

| Festivals / Rituals | Period of celebration | Corresponding local month | Associated with purpose | Plant species used in the festival/ritual |
|---|---|---|---|---|
| *Losar* | February-March | Dawa Dangpo | New year | Conifers leaves |
| *Choekar* | April-May | Dawa Sumpa | Religious | Conifers leaves, Wheat, Maize |
| *Jonklon* | April-May | Dawa Sumpa | Agriculture | Maize, Wheat |

| | | | | |
|---|---|---|---|---|
| *Kro-Choekar* | May-June | Dawa Jipa | Agriculture | Conifers leaves, *Artimesia* |
| *Wang* | June-July | Dawa Gupa, and Dawa Ngapa | Religious | Conifers leaves |
| *Phudo Songba* | August and also Round the year | -- | Traditional ritual | Maize, Wheat |
| *Potenya* | September-October | Dawa Gepa, and | Agriculture | Maize, Beans, Wheat |
| *Rek Lapsang Chhongba* | September-October | Dawa Gepa | Agriculture | -- |
| *Wang* | October-November | Dawa Gupa, and Dawa Ngapa | Religious | Conifers leaves |
| *Khiksaba* | November-December | Dawa Chupa | Indigenous festival | Bamboo, Pine, Betel nut and leaves |
| *Ba jung Khloba* | November-December | Dawa Chupa | livestock wellbeing | Conifers leaves, Maize, Wheat |
| *Torgya* | January | Dawa Chungnipa | Religious | Wheat, Maize, Conifers leaves |

- Listing of faunal species following IUCN categories is carried out. Major endangered species found in the landscape are Snow leopard (*Unicia unicia*), Musk deer (*Moschus moschiferus)*, Common Leopard (*Panthera paruds),* Tiger (*Panthera tigris)*, Asiatic Black Bear (*Urasus thibetanus)*, Arunachal Macaque *(Macaca munzala)*, Capped langur (*Trachypithecus pileatus)* and Himalayan Goral *(Naemorhedus goral).* The various animal body parts, that are traditionally used by the Monpas in food, therapeutic purposes, traditional medicine and storage of food grains were also documented. Some of the mammalian species are not hunted due to the taboos and belief associated with them.

## Migration: its socio-economic and cultural implication in Indian Central Himalaya *(2009-2012, In-house)*

Though population migration to affluent areas is a common phenomenon, it is rampant in hill regions like Uttarakhand. The quality and direction of migration as well as its economic, social and cultural impacts on the life of communities have changed along with the increase number of migrants in the state. Migration is a complex and dynamic process and plays a significant role in establishing the socio-economic structure of particular region as well as defining the mode of development with the region specific economy. While migration may be considered as a positive indicator of regional development, out migration of particular age group from the state like Uttarakhand creates regional imbalance adversely impacting agricultural productivity, therefore, the economy of the region as out migration results in loss of larger proportion of able, educated and active work force.

### Objectives

- To assess the impact of out-migration on natural resources and ecology.
- To understand the linkages between social infrastructure and resource scarcity with migration.
- To analyze economic characteristics of migration for possible development of entrepreneurship.
- To evaluate implications of migration on economic and socio-cultural issues like gender

### Achievements

- Selection of study villages has been completed. Initially, four villages - Dallakote, Sangyadi, Dhaulla and Shella - from Bhashiyachhana block in Almora district are being studied.
- Preliminary investigation in the study villages revealed that the villages are prone to out migration because of their disadvantaged location, poor economy and lack of viable alternate livelihood options. Agricultural production in the villages can sustain the food requirement of the villagers for about 3-5 months, therefore, forcing the people to migrate to urban/ sub-urban areas for seasonal employment.
- Further, it has been observed that apart from economy poor social infrastructure, i.e., health and education in particular, is another factor for outmigration. For example, out of the total 30 families of Dallakote villages, 13 families migrated in search of livelihood, better education and health. Similarly, from 5 households Dhaula village and 3 households Shella village out-migrated.
- Apart from permanent out-migration, able bodied males are also migrating seasonally as 18, 9 and 11 persons out-migrated from Sangyadi, Dhaulla and Shella villages, respectively, in search of engagement at elsewhere.
- Necessary linkages have been established with block and district administration in order to investigate the impact of national programmes like NAREGA on out migration.

## Pesticide Residue Contamination of Food Chain: Appropriate Monitoring and Control Measures from Field studies in Himachal Pradesh *(2009-2012, In-house)*

Himachal Pradesh is well advance in horticulture and agriculture, and numbers of pesticides are frequently used since last few decades to control the pests and diseases on crops and to increase their productivity. Study of Dr. Y.S. Parmar University of Horticulture and Forestry, Solan showed that the residue level of Chlorpyrifos in cabbage, okra and grapes, and cypermethrin in okra exceeded their MRL (maxiumum residue levels) values. Detectable amounts of chlorpyrifos, endosulfan and cypermethrin were also found in other tested crops collected from various districts of Himachal Pradesh. The past studies have clearly shown the evidence of maximum residue levels of cypermethrin, α-HCH and γ-HCH in the honey samples collected from Kullu. Therefore, studies on the monitoring of pesticide residues accumulation in food chains of the north western Himalaya particularly in Kullu district of the Himachal Pradesh are essentially required so that adequate planning could be made to minimize the exceeded levels of pesticide residue in edible portions of crops.

### Objectives

- To quantify pesticide residue levels in soils, water and in crops grown locally and sold in local markets.
- To assess dietary exposure of local consumers to pesticide residue through contaminated crops and their health risks by comparing the generated database with their maximum residue limits (MRLs).
- To assess effect of household practices on accumulation of pesticide residue levels in edible part/s of crops grown locally and sold in markets.
- To assess the effect of organic matters on accumulation of pesticide residues in edible part/s of crops grown on contaminated soil

### Achievements

- Pesticides are distributed @ 12943 kg per year i.e. April-March to local farmers of Kullu, which ranged from a minimum of 1463 (kg +L) to a maximum 24520 in 2007 and 2008, respectively (Table-21).
- A large number of pesticides such as monocrotophos 36% SL, dimethoate 30% EC, cypermethrin 25%, 10% EC, endosulfan 35% EC, diclorvos 76%EC, chlorpyrifos 20%EC, mancozeb 75% WP, copper oxychloride 50% WP, copper sulphate, capton 50%SP, 2,4-D Na salt 80%, butachlor 50% EC, carbendazim 50%EC are used by the farmers for their cash crops such as apple, tomato, cauliflower and cabbage. A few farmers are also using combinations of insecticides like Cannon (chlorpyrifos 50% + cypermethrin 5%EC). The amounts and frequency of pesticide applications on these crops vary from 2.5 – 2.75 L $spray^{-1}$ $ha^{-1}$ and 1 - 20 times, respectively in the area.
- Questionnaire based surveys at Kullu, Anni, Banjar and Naggar showed that the marginal farmers have poor knowledge on pesticide use, pesticide

**Table-21:** Year wise pesticide distribution (kg / L) to local farmers of Kullu, Himachal Pradesh

| Years | Quantity of pesticide distributed to farmers | | |
|---|---|---|---|
| | Quantity (kg) | Quantity (L) | Total (kg+L) |
| 1998-1999 | 9229 | 820 | 10049 |
| 1999-2000 | 17620 | 820 | 18440 |
| 2000-2001 | 16589 | 710 | 17299 |
| 2001-2002 | 17065 | 930 | 17995 |
| 2002-2003 | 12196 | 1710 | 13906 |
| 2003-2004 | 6435 | 1595 | 8030 |
| 2004-2005 | 10132 | 964 | 11096 |
| 2005-2006 | 9167 | 526 | 9693 |
| 2006-2007 | 9465 | 412 | 9877 |
| 2007-2008 | 24107 | 413 | 24520 |
| 2008-2009 | 1288 | 175 | 1463 |

(Data source: District Agriculture Department, Kullu, Himachal Pradesh)

contamination of their crops, water, soil and its impact on human health. The survey results further showed that toxic chemical pesticides such as carbendazim, cypermethrin, chlorpyrifos and endosulfan are used by 64, 58, 57 and 37% of the interviewed farmers. Most of the farmers are not using any protective gears or clothing during the pesticide spray (Fig.55).

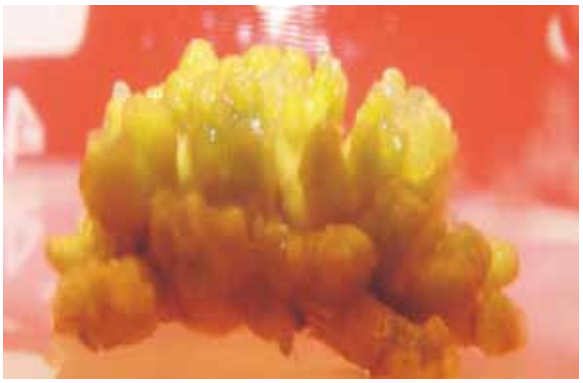
- The consumption rates of cauliflower, tomato and apple were found 121, 116, 23 g (fresh weight) / person/day for male and 119, 116 and 20 g (fresh weight) /person/day for female inhabitants of Kullu district of the Himachal Pradesh.

**Fig.55.** Mixing of pesticides; Photograph 1b: Spray of pesticides in apple orchards



## Theme

# BIOTECHNOLOGICAL APPLICATIONS (BTA)



The broad activities of the theme are based on identification, documentation and applications of the bioresources of Indian Himalayan Region (IHR). Studies comprise mainly on three major groups of bioresources, viz. plants, animals and microorganisms. The plants are the primary producers; therefore, a thorough understanding of the factors that govern their productivity and functioning is of paramount importance especially in the light of severe climatic conditions prevailing in the Himalaya, and current concern about the global climatic change. An understanding of the mechanism of plant adaptation to stress, be it physiological, biochemical or molecular aspects, is extremely relevant for increasing productivity of the plants. Plant propagation packages, addressing the need of local people, have been developed using conventional and biotechnological tools; phytochemical and molecular profiling of medicinal and aromatic plants are also being carried out.

Documentation of animal and microbial diversity is equally important. A study on diversity and locally useful species of fish is underway in Arunachal Pradesh. Exploration on microbial diversity with special reference to rhizosphere microorganisms has been carried out which has led to the formulation of carrier based bioinoculants for mountains. The microorganisms that thrive under extreme environments, from polar deserts to geothermal springs, are referred as extremophiles. Psychrophiles and thermophiles, in particular, have received special attention and are being explored for their diversity, biotechnological applications and the strategies adapted for survival under extreme climatic conditions of IHR. The theme envisages to: i) identify and document bioresources of applied value of the IHR, ii) generate technological know-how of the process development, and iii) build capacity of the human resource.

### Assessment of Microbial Diversity in Himalayan soil and determination of Potential Applications *(2007-2012, In-house)*

Systematic studies have been initiated in this laboratory on isolation, identification and characterization of microbial communities of the region about 15 years ago. While the temperate and alpine locations have been explored for enumerating the diversity of free-living bacterial, actinomycetes and fungal communities, the symbiotic associations between selected trees and the arbuscular mycorrhizal fungi have been investigated. Investigations have also been carried out on microbial diversity of the hot spring sites, located in the Garhwal Himalaya. Microbial inoculants suitable for colder regions of mountains have been developed. The present proposal has been formulated on the basis of the leads obtained from the earlier work done carried out in the area of microbial diversity of IHR with a focus on: (1) rhizosphere microbial communities, and, (2) extremophiles. In addition, work has been initiated on one microbiology based activity for NE region.

#### Objectives

- Assessment of diversity of microorganisms growing in extreme conditions (thermophiles and psychrophiles) of Indian Himalayan Region.
- Determination of potential applications of selected microorganisms with an emphasis on production of secondary metabolites and enzymes.
- Preservation of pure cultures in the Institute's laboratory and accessioning of selected cultures in National and International Culture Collections and Gene Banks.
- Initiation of HQ and NE unit collaborative study on "Influence of fire process during shifting cultivation on soil microflora and nutrients".

#### Achievements

- The effect of inoculation with an endophytic bacterium, isolated from cortical cells of *Ginkgo biloba* roots, has been studied with a view of its plant growth promoting potential. Bacterial inoculation resulted in

enhancement in plant growth related parameters, such as biomass, chlorophyll content, etc. Large number of plants of *G. biloba*, using this bacterium in broth based formulation, has been raised under net house conditions.

- A new investigation on microbial communities in river Jataganga (Jageshwar, District Almora) during festival and different seasons has been initiated. Besides enumeration, about 300 pure microbial cultures have been isolated. These mainly include coliforms, non coliforms, biological indicators, pathogens and soil / rhizosphere. Many species of *Escherichia coli* (water borne) and of actinomycetes (soil borne) have been observed.
- Selected cultures of bacteria, actinomycetes and fungi have been accessioned by MTCC, IMTECH, Chandigarh; ITCC, IARI, New Delhi and Agarkar Institute, Pune. The gene sequences of the important isolates have been accessioned by NCBI.
- Soil samples collected after fire operations at agricultural sites under shifting cultivation in northeast India were subjected to physico-chemical and microbial analysis. The bacterial and actinomycetes counts were significantly higher in fired plots as compared to the fallow plots. The representative bacterial species recovered from the 'fired plots' belonged to the genus *Bacillus* and *Pseudomonas*. Recovery of these bacterial species, after fire operations, is an indicative of the microbiological merit of shifting cultivation.

## Development of propagation protocols, multiplication and field evaluation of selected economically important plants in Indian Himalayan region *(2007-2012, In-house)*

The Indian Himalayan region is a home to a large number of economically and ecologically important plants, including non-timber forest products. With ever increasing human population along with growing demand for plants and plant based products, there has been tremendous anthropogenic pressure on these primary producers. In order to cope with such challenges, large scale plantations need to be taken up. Therefore, large scale multiplication of quality planting material would be required. Besides conventional methods of propagation, in vitro propagation techniques have the recognized potential for rapid multiplication of elite clones not only to provide the much needed planting material for cultivation to derive economic benefits but also for restoration of degraded land and conservation. Keeping these goals in mind, investigations have been undertaken on various target species based on local demand, and results of different studies taken up during this year has been reported.

Target species: *Zanthoxylum armatum* DC [syn Z. *alatum* Roxb. (Rutaceae)], *Amomum subulatum* Roxb. (Zingiberaceae) - HQs; *Quercus* spp. (Fagaceae), *Rhododendron* spp. (Ericaceae) - Sikkim unit; *Olea ferruginea* Royle (syn. *O. cuspidata* Wall. ex G. Don. (Oleaceae)] - Himachal unit, Kullu. All are economically important species.

### Objectives

- Comprehensive base line information, germplasm collection and maintenance in nursery.
- Development of propagation protocols by conventional (by cuttings and seeds) and *in vitro* methods.
- Large scale propagation of *R. maddeni* and *R. dalhousiae* plants for conservation using existing protocols
- Large scale multiplication and field performance of transferred plants.
- Analysis of chemical constituents.
- Training of students, farmers and villagers.

### Achievements

- Tissue cultures of *O. ferruginea* were developed using apical shoots and nodal explants from mature trees. Murashige & Skoog's (MS) medium containing half strength salts, BAP or kinetin and NAA or IAA were found suitable for bud break; following shoot multiplication these shoots were rooted.
- Air wet technique method of vegetative propagation has proved successful in *Rhododendron arboreum*, *R. dalhousiae* and *R. griffithianum*. This method along with using stem cuttings (leafy) was also attempted for *Q. lamellosa* and *Q. pachyphylla*. Use of chemicals to induce root formation in stem cuttings of these 2 species has also been attempted.
- Comparison on some physiological parameters of *in vitro* raised (IVR) and seed raised (SR) plants were carried out. SR plants had thicker leaves than IVR plants. Higher leaf area and plant height (cm) was recorded in IVR plants (51.77 $cm^2$ and 89.00 respectively as compared to 41.62 $cm^2$ and 81.67 for SR plants). Chlorophyll 'a' content was higher for SR plants (1.20 mg/ g FW as compared to 1.11 mg/ g FW in IVR plants) while chlorophyll 'b' content was slightly higher in IVR plants. Percent relative water content of

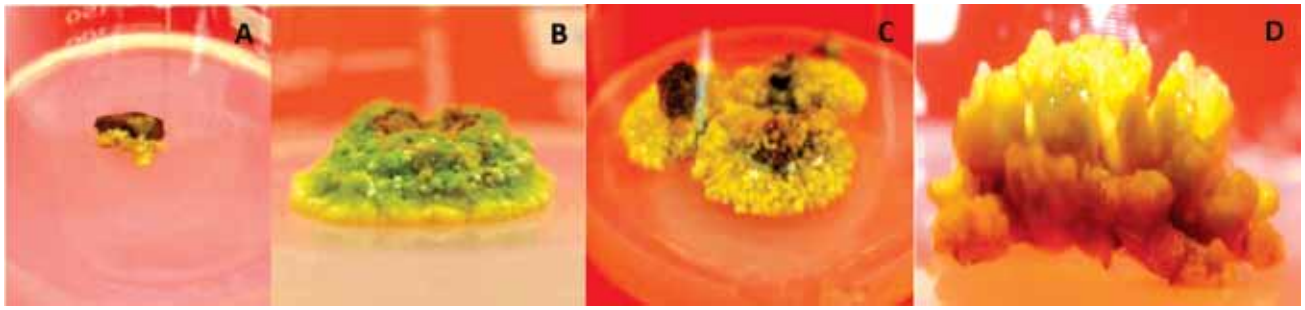



**Fig. 56.** Different stages during callus proliferation and plant regeneration via somatic embryo formation in *Q. lamellosa* on Woody Plant medium. (A): Induction of callus on the surface of cotyledon segments of immature embryos, (B): Four weeks old green compact callus, (C): Ten weeks old callus grown on the same medium, and (D); formation of nodular structures on the callus surface.

leaves was essentially similar for both sets of plants. The IVR plants were by and large comparable with seed raised plants in terms of growth, stomatal size and frequency, and chlorophyll content.

- Callus proliferation and plant regeneration via somatic embryo formation in *Q. lamellosa* is in progress. Around 22 combinations of auxin/cytokinin (auxin: 0.45-4.5 µM; cytokinin: 2.2-22.2 µM) and gibberellin/ cytokinin (gibberellin: 0.29-2.9 µM; cytokinin: 2.2-22.0 µM) has been tested for the germination of somatic embryos (Fig. 56A-D).

- Conventional method of propagation was attempted to multiply of *Z. armatum*. Treatment of stem cuttings (15-20 cm) with various chemicals (NAA, IBA, Coumarin & Bavistin) and planted in polybags and/ or soil under polyhouse conditions. Root formation was observed in some; however, callus formation occurred at the base of several cuttings. Air layering method was found to be suitable for propagation of this species and a seasonal influence was observed; this technique is being used for multiplication.

- Multiple shoots of *A. subulatum* were cultured on the MS medium containing cytokinins. Effective and maximum shoot proliferation was obtained on MS medium supplemented with 0.5 µM BAP and 1.0 µM kinetin; the shoots were multiplied and subsequently rooted to produce plantlets.

## Molecular characterization of selected medicinal plants of Himalayan region *(2009-2012, In-house)*

Himalayan region is a rich reservoir of valuable resource of medicinal and aromatic plants along with the other economically important plants. One hundred and seventy five out of 280 medicinal plants which are mostly used by pharmaceutical industries are from IHR. Some of the well known economically important plants of Himalayan region are *Taxus baccata, Aconitum heterophyllum, A. balfourii, Podophyllum hexandrum, Picrorhiza kurrooa, Valleriana wallichi, Pinus roxburghii, P. gerardiana, Zanthoxyllum armatum, Swertia angustifolia, Angelica glauca, Heracleum candicans, Ginkgo biloba,* etc. possess biologically active compounds, and secondary metabolites have been identified and purified from these plants. In order to identify genetically high yielder in terms of their active component (source of anticancerous drug podophyllotoxin, ginkgolites- used in recovery from memory loss, and antimalarial drug artemisinin) in medicinal plants, an attempt has been made to formulate this project.

### Objectives

- Collection and maintenance of germplasm
- Development of morphological, chemical and molecular profile

### Achievements

- Initially three medicinal plants were chosen.
  1. *Podophyllum* species
     a) *P. peltatum*
     b) *P. hexandrum*
     c) *P.sikkimensis*
  2. *Ginkgo biloba*
  3. *Artemisia annua*
- Inter and intra specific molecular diversity was estimated in *Podophyllum* species
- Species specific markers were identified in *Podophyllum,* cloning was done to convert them in to SCAR (sequence characterized amplified region).
- Morphological and chemical profiles of *Podophyllum* were developed.
- Sex specific primers were designed to identify male and female plants in *G. biloba*
- Random block design trial was carried out to check the artimisinin content in *A. annua* growing at a low-hill region (GBPIHED, Kosi-Katarmal; 1150 m).

## Identifying the environmental correlates leading to reproductive success of fishes for enterprise development of lotic stream fishery *(2008-2012, In-house)*

Arunachal Pradesh is known for its rich biodiversity; a large part of state still remains unexplored and the diversity of both floral as well as faunal elements remains largely non-documented. Even where report exists, many groups remain unstudied. The state has many major rivers and numerous rivulets and streams dissecting the topography, offering diverse habitat to aquatic life. While some rivers of the state have been surveyed for their ichthyofauna, many remain unexplored even today. Senkhi is one of the important streams of the capital town, Itanagar, Arunachal Pradesh, which caters to 70% of the water needs of the urban population. It also contributes 38% of the Icthyofauna of the state and also reported addition of eight new species for the district, four for the state and one new species to science. Senkhi consists of varied microhabitats ranging from deep waters to fast-flowing riffles. It is a perennial stream and hence is important to cater to the day-to-day needs of the urban populace. There has been noticeable reduction of vegetation cover in the catchment areas, which has resulted in low discharge of the once fast stream. The fish are part of the tribal folklore and forms an important source of food. Most of the fishes captured in the state serve to the subsistence needs of the people, and increasing demands for fishes are met through imports outside the state. There is dearth of awareness regarding the commercial breeding activities, government schemes and benefit seldom percolates to the deserving population. Therefore there is a need to understand the locally favorable species in all aspects to foster their culture for benefit of the local people.

### Objectives

- To identify the ambient environmental parameters of water for different species of fishes.
- To carry out regular population estimates of fishes over sampling period.
- To study the behavioral and morphometric parameters of fishes and correlate the same with their population parameters.
- To identify the fecundity of fishes over the sampling period.
- To prioritize the fishes based on their reproductive success and population parameters for enterprise development.

### Achievements

- Three sites were identified for sampling upstream, midstream and downstream. Monthly water quality analysis reveals that the ambient air temperature (°C) followed an increasing trend from upstream (19.53±0.88) to downstream (20.32±0.72). Water temperature shows a similar pattern with values increasing from 14.2±0.11 to 18.12±0.13 in upstream and downstream respectively.
- On the other hand pH values followed a reverse trend increasing in upstream and gradually decreasing towards the downstream; the pH from upstream towards downstream ranged between 6.32-6.12. Organic matter (%) showed trends similar to that of pH and varied from 0.39-0.68 from upstream to downstream. Nitrate nitrogen, ammonical nitrogen and phosphate values (in µg/g) showed an increasing trend with decreasing elevation. Biochemical oxygen demand, however, revealed a reverse trend as the mean values were higher in upstream (0.92), midstream (1.22) and downstream (1.31).
- The catch frequency yields the *Barilius bendelesis* has catch frequency of 100%, followed by *Aborichthys elongatus* and *Psilorhynchus balitora* at 93%, *Garra gotyla* and *Garra annandalei* has frequency of 80%, *Botia rostrata* is having catch frequency of about 65% (Fig. 57).

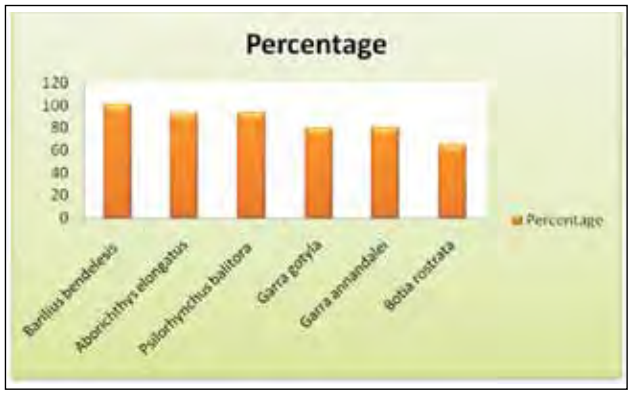



**Fig.57.** The dominant species of fish as determined by their frequency of capture in Senkhi stream of Itanagar, Arunachal Pradesh

- The most successful species in terms of catch frequency is *Barilius bendelesis*. Gut content analysis of this species indicates that food intake is chiefly phytoplankton and zooplankton. Diet composition of this species suggest that it takes chiefly chlorophyceae (50%) followed by bacillariophyceae (35.71%) and zooplankton (14.28%); (Fig. 58).

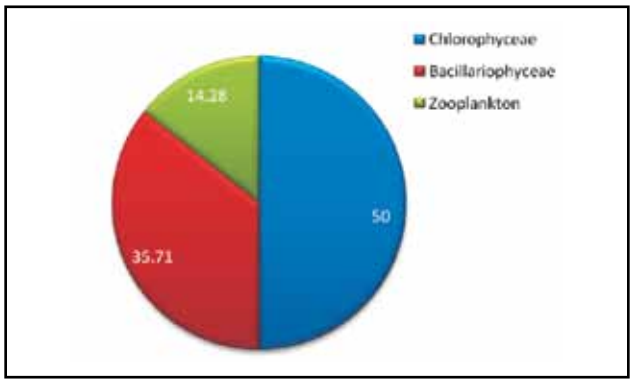



**Fig.58.** A chart depicting the gut content analysis (plantkton feeding species) of a dominant fish species *Barillus bendelesis*

## Phosphate solubilizing fungi in Himalayan soil: Diversity and applications *(2010-2013, DST - Young Scientist Scheme)*

Microorganisms play a fundamental role in the biogeochemical cycling of phosphorus in natural ecosystems. Since phosphate solubilization is a prime process for plant growth, the importance of phosphate solubilizing microorganisms is well recognized. Temperature, pH and biomass are vital factors for carrying out various activities of microorganisms. The major microbiological process by which insoluble phosphorus compounds are mobilized is by the production of organic acids. Literature on microbial diversity of colder regions is scanty. The aim of the present project is to determine phosphate solubilization and litter decomposition potential of the dominant fungi, isolated from Himalayan soil.

### Objectives

- Phenotypic and genotypic characterization of fungal cultures isolated from temperate Himalayan soil.
- Screening and selection of efficient phosphate solubilizing fungi, with special reference to litter decomposition and plant growth promotion.
- Demonstration of the preparation and usage of carrier based formulations of efficient fungi to the target people of Indian Himalayan Region (IHR) (participatory technology development).
- Dissemination of the technique to the local people through booklets and people's participation.

### Achievements

- Cold tolerant phosphate solubilizing species of *Aspergillus*, *Penicillium* and *Paecilomyces*, isolated from the high altitude soil of Indian Himalaya were considered for detailed investigations on phosphate solubilization efficiency at different temperatures. These species exhibited tolerance to wide range of pH and temperature. Species of *Aspergillus* were found to be the best solubilizers, followed by *Penicillium* and *Paecilomyces*. The phosphate solubilization related parameters (reduction in pH, production of biomass, and phosphatase activity) were found to be temperature dependent.
- Plate based assays have been conducted for screening of cold tolerant fungi in order to assess their biodegradation potential. Many species showed positive results for laccase activity.

## *In-vitro* propagation and conservation of some rare and endangered Rhododendrons species of Sikkim Himalaya *(2009-2012, CSIR, New Delhi)*

The genus *Rhododendron* is represented by about 85 species in India; it is mainly distributed in the Himalayan region (one species, *R. nilagiricum* in South India). Out of this, a total of 36 species with 45 different forms, including subspecies and varieties, occur in Sikkim alone. A total of fourteen rhododendron species (*Rhododendron baileyi, R. campanulatum* subsp. *aeruginosum, R. decipiens, R. fulgens, R. virgatum, R. dalhousiae* var. *tashi, R. griffithianum, R. leptocarpum, R. maddeni, R. niveum, R. pendulum, R. thomsoni* var. *flocculosum, R. pumilum* and *R. sikkimense*) from the Sikkim Himalaya have been listed as critically endangered (CR) or vulnerable (V). Steady decline in the number of species and drastic changes in their natural habitat, as well, as in some cases, complete population annihilation in the wild has become a strong issue of concern, and a compelling reason to start work on the conservation of rhododendrons in the region. The rise in human population with demand on land for farming, fuel wood needs, increased animal husbandry practices, construction of roadways, hydel power projects and allied works, and of late the tourist influx have collectively resulted in building up of considerable pressure on the very survival of *Rhododendron* species. Under the circumstances, it was though relevant to initiate efforts for conservation of Rhododendrons to save the existing germ pool of this keystone genus of the Himalayan region. Maintaining viable populations of Rhododendron species is a crucial factor in conservation efforts, and this calls for adopting appropriate conservation approaches, including as *ex-situ* and *in-situ* methods.

### Objectives

- Collection of seeds, shoots and twigs for proliferation.
- Use of both conventional and *in vitro* methods for propagation and *in vitro* germplasm conservation for a few selected rare and endangered rhododendron species.

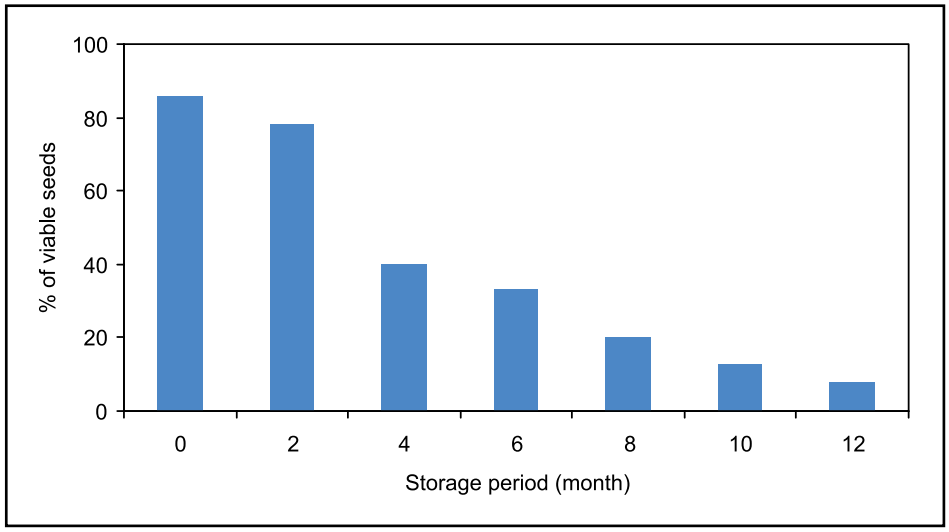



**Fig.59.** Changes in seed viability of *R. niveum* during storage at 4ºC

- To develop efficient *in vitro* propagation protocol for mass propagation of a selected number of rare and endangered species.
- Production of plants for which protocol(s) has been developed
- Test trials of seedlings, raised through tissue culture, in arboretum and fields conditions.

### Achievements

- Seeds of *R. niveum* Hook. f. were collected in October 2008 from Yakchey (North Sikkim, (27° 43' N and 88° 45' E; 3500 m amsl). Immediately after collection, capsule were dried at room temperature for 1 week, and then stored in small plastic bags at 4°C.
- In view of the low germination rates, seed viability test was carried out using tetrazolium, which showed that 86% of the seeds were viable at the time of collection, however, after two months of storage at 4°C the viability decreased significantly ($P = 0.05$) and by the end of twelve months, it was only 8% (Fig. 59).
- Various seed treatments were attempted for improving germination percentage; the results are awaited.

## Assessment of biodiversity values and ecosystem services in the protected areas of Sikkim Himalaya *(2009-2013, ICIMOD)*

The Kangchenjunga landscape, shared by Bhutan, PR China, India and Nepal is one of the most important transboundary landscapes in the eastern Himalayas. The designation of 42% of the southern part of the landscape under protected area network with an additional 11% as proposed corridors makes the landscape an important biodiversity repository. Many of these protected areas are still unexplored or there is limited information on the biodiversity they harbor. In addition, the management effectiveness of these protected areas for biodiversity conservation has been questioned due to prevailing climate change scenario which is bringing more uncertainties and challenges in the region for effective biodiversity conservation. Under the influence of climate change the vegetation composition and community structure will change, and so will the associated functionalities and the related eco-system services which may adversely affect the human welfare, and could lead some of the traditions and cultural traits/ practices to oblivion. The project is a part of LOA signed between ICIMOD and the GBPIHED on Biodiversity Conservation in Transboundary Landscapes which has a focus on the protected areas of Khangchendzonga Transboundary Landscapes. The proposed project tends to study and document the status and changes in the biodiversity and ecosystem services of the protected areas in light of climate change and to see its implications for the society.

### Objectives

- To fill in the knowledge gaps and have a better understanding of biodiversity resources of the three protected areas that have data gaps
- Assess the human perception on impact of climate change to biodiversity and livelihoods for enabling local communities better adapt to climate change
- Review the services provided by the protected areas and its implications for vulnerable mountain communities living in the region.

## Achievements

- Three Protected Areas (PAs), namely, Fambonglho Wild Life Sanctuary (WLS), Kyongnosla WLS and Pangolakha WLS have been identified after thorough consultation with the Forest Department, Govt. of Sikkim.
- Local views and methods of their coping/adaptation on climate change from the adjoining protected areas have been generated through PRA and questionnaire based surveys.
- Collected information on perception of local people on climate change for compilation of data for analysis.

### *Summary of Completed Project/Activity*

### Development of callus and hairy root cultures as strategy for production of active compounds from two Himalayan alpine medicinal plants *(2007-2010, UCOST)*

Indian Himalayan region harbours a large number of medicinal and aromatic plants which are sources of active compounds for the preparation of high value drugs. Due to increasing demand of these plants by the pharmaceutical companies, they are being subjected to reckless, often illegal harvesting, well beyond their natural regeneration capacity. Although conventional and biotechnological methods have proven to be promising for multiplication and subsequent cultivation of many of these species, use of callus cultures and genetically transformed hairy roots for production of active ingredients of medicinal value would be attractive alternative. Use of genetically transformed hairy roots, produced by gram negative soil bacterium *Agrobacterium tumefaciens*, has been reported to be promising for secondary metabolite production in many plant species. Therefore two economically important species, namely, *Picrorhiza kurrooa* and *Aconitum heterophyllum* have been selected for this investigation.

## Objectives

- Establishment of callus and hairy root cultures
- Analysis of active ingredients
- Scaling up cultures for the production of active ingredients.

## Achievements

- Callus cultures of *P. kurrooa* developed from leaf and nodal segments have been scaled for analysis of growth and active ingredients.
- Hairy roots initiated and developed (following infection with *Agrobacterium tumefaciens*), and confirmed for transformation by PCR analysis have been scaled up. Among different types of medium used (full strength MS liquid, half strength MS liquid and solid medium, containing 3% sucrose) to determine maximum growth of hairy root lines (8 lines) during 1-8 weeks culture, best growth was achieved in ½ strength Murashige & Skoog's liquid medium.
- In all the lines, slow growth occurred in the first 2 weeks followed by a gradual increase in the next 6 weeks; subsequently the cultures showed a stationary/ declining trend. In most of the lines better growth with higher biomass was achieved during 3-6 weeks of culture in ½ MS liquid medium and maximum (16.82 g FW) was recorded in line-4, whereas minimum (13.85 g FW) was recorded in line-3.
- Production of active ingredients (based on picrotin and picrotoxin standards) during culture were determined in all the samples (runners, callus & hairy root lines) following extraction, purification and subsequent analysis by HPLC.
- Among these hairy root lines (line-1 and line-4; 6 weeks following growth), line-4 was most suitable in terms of hairy root biomass as well as secondary metabolite production. Maximum concentration of picrotin (8.8 µg/g DW) was recorded for line-4, followed by line-1 (4.5 µg/g DW). Moreover, maximum (47.1 µg/g DW) picrotoxinin was recorded for line-4, while in one of the callus lines (raised separately) examined very low quantity of picrotoxinin was recorded (1.7 µg/g DW). In the natural runner (control), picrotin and picrotoxinin levels recorded were 0.6 µg/g DW and 6.7µg/g DW, respectively.
- The results of this finding/study have commercial applications, and will not only reduce the pressure on the natural plant population but can also bring economic benefits to the state.

## Theme

# KNOWLEDGE PRODUCTS AND CAPACITY BUILDING (KCB)

There are hundreds of different culture in the Indian Himalayan region, each with its unique practices and way of looking at life. Through their reliance on and interaction with ecosystem and natural resources, traditional societies and local communities have acquired an immense knowledge of their natural environment. With greater realization of the value of this knowledge base, for looking at issues linked to social process and natural resource management there is increasing realization that in many ecological/ social situations, knowledge should be an integral part of a holistic and cost-effective approach to sustainable development. The knowledge accumulated, documented, produced/developed over a period of time in any field for human well being and natural resource management, is required to be transmitted or exchanged through capacity building efforts in empowering all the stakeholders The level of understanding, skills, enthusiasm and values of the user groups are considered key factors in stimulating the learner's interest and appreciation of implementation of knowledge produce. In addition, one must consider a number of other factors including policy and regulation environment, nature of resource base, local capacities, external support, and prevailing natural resource management practices that considerably influence the effectiveness of the integrated knowledge base and its implementation. Knowledge base of the different traditional societies and knowledge developed through science and technology interventions, if successfully adopted/implemented, would certainly generate ecologically sound, economically viable, socially acceptable and institutionally enforceable outputs.

The KCB aims to improve the livelihood of the Himalayan people by strengthening and improving knowledge systems of all its different sectors/aspects, developing economically viable community based organization and promoting sustainable management and use of local resources. It seeks to promote research through participatory and action mode and integrate, mobilize and share research and developmental findings for sustainable development of the Himalayan region. The objectives of KCB theme are: Documentation of knowledge system related to agriculture, natural resource management, traditional healthcare, medicinal and aromatic plants, wild edibles etc. for livelihood enhancement; Land rehabilitation models using traditional and modern knowledge systems; Livelihood enhancement through sustainable farming systems; Eco-friendly and hill specific technologies based on local bioresources for enterprise development and capacity building. The outcome of the studies provide opportunity for stakeholders to interact with each other and with institutions working on knowledge products system together to address research, action, and policy needs and help to develop appropriate strategies and guidelines for sustainable mountain development.

### Strengthening fodder resources and developing a pilot model for reducing drudgery of rural women in Kedarnath Valley, Uttarakhand *(2009-2010, DST, New Delhi)*

Collection of fodder is the first step that turns the wheel of the agricultural economy of the village community in the Himalayas. Agriculture along with animal husbandry is the principal occupation and source of livelihood for over 70% of the population of Uttarakhand state, India. Garhwal part of Uttarakhand faces a huge amount of fodder deficiency every year. This area is remote in its accessibility as well as high pressure zone in terms of fodder removal. In this region, women are mainly responsible for the collection of fuelwood and fodder. The most serious problem is the unavailability of green forage, particularly in winter and adds to the drudgery of local women folk of Central Himalayan Region (CHR). The condition of local women is pathetic. Hence, this project concept was born and was thought that it can be a source to relieve the pressure on women by lowering their time of fodder collection. This will also decrease the distance they travel and generate awareness among them related to the better methods of feeding livestock and fodder quality.

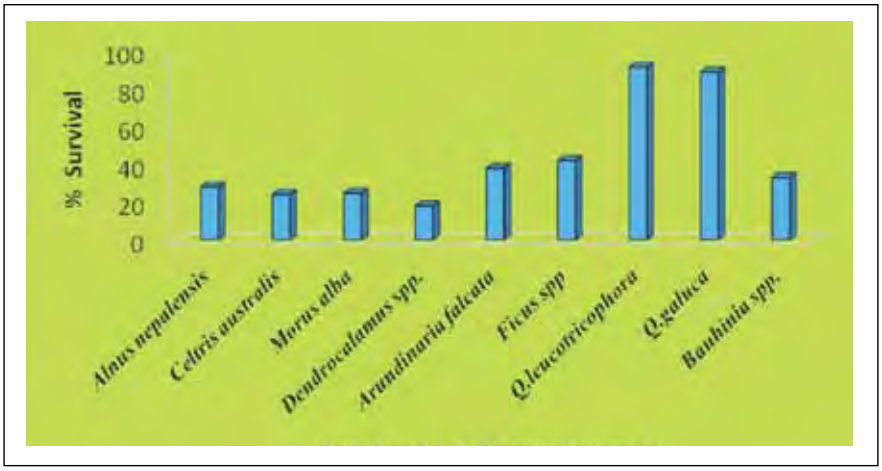



**Fig. 60.** Survial % of different fodder species

## Objectives

- To screen and propagate promising fodder species on community lands.
- To rehabilitate village commons with people's participation and develop a fodder based pilot model for replication.
- To build capacity of the women for strengthening fodder resources within village ecosystem.
- To suggest a workable strategy for replication of fodder-based approach for reducing drudgery of hill women.

## Achievements

- Different fodder species were prioritized and selected based on the meetings and group discussions held with local communities of village Maikhanda in Rudraprayag District.
- Results illustrated that *Quercus leucotricophora* exhibited the maximum (91%) survival percentage whereas, the minimum (18%) survival was recorded for *Dendrocalamus spp*. (Fig. 60).
- Concept of project itself is innovative and PI received Best Innovator award for the paper entitled "Strengthening fodder resources and developing model for reducing drudgery of rural women in Kedarnath Valley, Uttarakhand" in 2nd *Yuva Vaigyanik Sammelan* 2010 in Dehradun.

## Sustainable Tourism: Assessing the Eco-Tourism Potential of Garhwal Himalaya *(2007-2012, In-house)*

In many places around the world where unique lifestyles and settings are threatened, people in various sectors are considering and using tourism as the sustainable industry of choice. Tourism is considered as one of the fastest growing industries world over. Within the industry, religious tourism has been identified as one of the oldest and fastest growing segments with the number of operators and tourists increasing worldwide. In the Himalayan mountain range, on the northern boundary of India, is the newly formed state of Uttarakhand has been identified as an area with grate tourism potential. It has high ecological, cultural, religious, spiritual values and has a long history in attracting nature lovers or eco-tourists. The enchanting diverse eco-geographical landscape and range of ecosystems decorated with astonishing variety of flora and fauna leave a lasting impression on tourist in Uttarakhand. During recent past Uttarakhand is facing intense development pressure and there is a desire from stakeholders for creative partnerships and institutional arrangements that permit the private and public sectors to play an important role in development of sustainable tourism. The pressure of tourism has been increasing and the state is in the process of exploring new sites or destinations for eco-friendly tourism or eco-tourism. Hence, the present study has been initiated in Upper Kedar valley of Garhwal Himalaya to assess the eco-tourism potential while involving local stakeholders of the region to demonstrate the better livelihood options.

## Objectives

- To assess eco-tourism potential of selected sites such as *Panchkedar* (Kedarnath, Mudmaheshwar, Tungnath, Rudranath and Kalpeshwar) and Triyjginarayan.
- To undertake analysis of environmental, social and cultural impacts of eco-tourism.
- To select a model of eco-trekking/eco-expedition routes of few potential sites.

- To create awareness, develop capacities and empower all the stakeholders at different levels in eco-tourism chain such that it results in a clean, green environment.
- To empower local communities to manage eco-tourism while linking it with local production system, development of eco-tourism products and other income generating activities.
- To develop a variety of advocacy and awareness, education and training materials, guidelines, policy recommendations and strategies and action plan for sustainable tourism/eco-tourism.

## Achievements

- Based on primary and secondary data analysis on socio-cultural impacts reveled that tourism has both positive and negative socio-cultural impacts on local people of the valley. Positive impacts include: improvement of various services such as health, telecommunications, banking, entertainment and infrastructure development i. e. widening of roads, operation of helicopter services, opening better hotels and lodges, and the involvement of local communities in tourism related income earning activities along the tourist routes. Negative impacts include: breaking of traditional family setups and relationships, increase in crime, adoption of modern clothes and a traditionally unacceptable 'vulgar' language by youth and competition for tourism related jobs between locals and immigrant communities.
- About ten (10) youth of two village's i.e. Shrishi & Triyuginarayan have adopted home-stay accommodation and they are now well familiar with the concept of home-stay accommodation. Very recently an exposure visit was organized for the youth involved in home stay accommodation from 5$^{th}$ to 8$^{th}$ March 2010 to village way (Almora) to provide them more insight and exposure in above field (Fig.61 & 62).
- Different approaches were developed and applied to improve capacity of local communities to manage their own resources and assets. This includes bioprospecting and value addition of cultivated crops and wild edibles. Few stakeholders have developed value added products from some potential wild edibles as a Kedar eco-tourism products.
- Limiting factors for carrying capacity of lodging in different destination (Kedarnath, Rambara, Gaurikund, Sonprayag, Sitapur, Rampur, Phata, Guptakashi and Triyuginaraya) in 35 km stretch were assessed and analyzed (Table-22).

**Fig. 61.** Organization of exposure visit for the youth involved in home stay accommodation from in the valley to village way (Almora).

**Fig. 62.** Youth sharing ideas and views with local of village way Almora for more insight and exposure about home stay accommodation.

**Table-22:** Limiting factors for carrying capacity of lodges/ hotels in different places between 35 Km distance

| S. No. | Name of the towns in UKV | Numbers of hotels/ lodges/rest houses | Accommodation | |
|---|---|---|---|---|
| | | | Carrying capacity of tourists accommodation | General practices of tourists accommodation occur during peak season |
| 1 | Kedarnath | 62 (803) | 3212 | 5000 |
| 2 | Rambara | 10 (42) | 168 | 250 |
| 3 | Gaurikund | 58 (615) | 2460 | 6000 |
| 4 | Sonprayag | 18 (220) | 880 | 800 |
| 5 | Sitapur | 19 (232) | 928 | 1000 |
| 6 | Rampur | 21 (245) | 980 | 1200 |
| 7 | Phata | 29 (290) | 1160 | 1300 |
| 8 | Triyugenarayan | 10 (26) | 104 | 104 |
| Total | | 237 (2447) | 9892 | 15654 |
| The accommodation currently available is most critical limiting factor. As per the accommodation available only 9892 person/ day can be accommodated but during peak tourist season the limit exceed beyond carrying capacity and it ranges between about16000 tourists per day in Upper Kedar valley. | | | | |

## Capacity building for entrepreneurship development and self employment in the Himalayan region *(2007-2012, In-house)*

The Himalayan region shows vast diversity, in respect of topography, natural and cultural landscape, climate, water availability, etc., therefore, a generalized and uniform development plan cannot be of much use in such a diverse area. Only the location specific management plans can be useful. A critical constraint in rural development is access to technology, particularly in regard to simple technologies for production enhancement and income generation. Demonstration of technologies and the requisite training of users were identified two crucial steps in the transfer of technology to remote/ rural areas where it is most needed. With this rationale a center which can act as a nodal point to collect information from various agencies/ institution/ individual experts and to disseminate this knowledge to target groups spread all over the Himalayan region was established in the Institute's old Campus at Kosi in the form of a project. Capacity building for entrepreneurship development and self employment in the Himalayan region. Capacity building through training, demonstrations of technology packages and field exercises of target groups carried out under this programme gained tremendous popularity and was appreciated by end users. It was found that this is a very important and successful step towards taking benefits of science to end users (Rawat, 2004).

### Objectives

The main objective of the proposed work is to improve the quality of life of the Himalayan people through efficient management of resources and to sustain optimum yield over a period of time using simple, low-cost, eco-friendly, and replicable technology packages. It should have a direct effect on drudgery reduction and overall well being of rural population. The proposed work is focus on the following objectives:

- To provide basket of hill specific technological intervention based on rural resource availability.
- Capacity building through trainings/ live demonstrations/ field exercises of stake holders and training of trainers (TOTs) on a regular basis.
- Guidance and support for field implementation of technology packages to the stakeholders and subsequent monitoring.
- To present a case study of peoples empowerment by adopting diverse options.
- To reduce out-migration by providing self employment options.
- To develop a frame work towards achieving self-sufficiency within the system in the long run.

### Achievements

#### *Head Quarters*

- A total of 39 technologies were collected, tested/ modified and maintained at the RTC (HQs), Maletha and Triyuginarayan (Garhwal Unit) with a view to replicate and/ or disseminate.
- During this period a total of 21 training/awareness programmes were organized for different stakeholders (at HQS) of which 8 training programmes were of one-day one of two days and 12 of three-day. The RTC was under renovation work from April 2009 to August 2009.
- A total of 780 persons (belonging to 105 villages and 6 districts of Uttarakhand) from various organizations/ institutions/ programmes were developed as a TOTs (Table-23).
- Technical guidance and necessary support e.g., planting material, good quality polythene for protected cultivation/water harvesting/ fish pond, etc. are being provided to selected progressive farmers for field implementation/demonstrations at various sites. Technical guidance/support for 8 polyhouses, 3 water harvesting tanks/ fishpond and 2 iron moulds for bio-briquetting, etc., were provided to the various SHGs during the reported period.
- Strong linkages were established with various stakeholders for wider field dissemination (Fig.63).
- Propagation of ecologically and economically important multipurpose plant species was carried out in the nursery for demonstration/plantation as well as for income generation.
- During this year 192 persons (05 Scientists & university teachers/Planners, 02 Army personnel, 163 Farmers and 11 country representative) were visited the RTC.
- The RTC has provided employment to the Nine (9) persons (6 persons at RTC & 3 persons for supported activities).
- Based on the participatory discussion, training manuals on various technology packages were prepared, and distributed to the farmers and user groups.
- During this year an amount of Rs. 4.2 lakh was generated through this programme.

**Table-23:** Training organized for different users (April, 2009 – March, 2010)

| Users | Total | Male | Female |
|---|---|---|---|
| Officials & Farmers selected by Govt. organizations | 427 | 345 | 82 |
| Institute programme | 175 | 19 | 156 |
| Students | 178 | 82 | 96 |
| Total | 780 | 446 | 334 |
| Districts covered | | 6 | |
| Villages covered | | 105 | |

**Fig.63.** Strong linkages were established with various stakeholders for wider field dissemination

### *Garhwal Unit*

- The participatory action research and training centre (RTC) Triyuginarayan got wide popularity and played a catalytic role in the capacity building of the user groups on various rural technologies introduced and developed. Five training programme were organized on "Demonstration/dissemination of rural technologies and conservation/management of natural resources" for local farmers of Kedar valley in which 312 farmers of Triyuginarayan & adjoining villages actively participated. During the reporting period unit also organized three paid training to the user groups (90 stakeholders/farmers) selected by Uttarakhand Parvatiya Aajeevika Samvardhan Company (UPASaC) from different districts of Uttarakhand (Tehri Garhwal, Chamoli Garhwal and Bageshwar).
- Strong linkages were developed with various GOs & NGOs and village institutions particularly those are concerned with rural development in the region. Many of the rural technologies those demonstrated huge economic benefits to local communities have been incorporated in the action plan of MANREGA, AATMA & rural development programme of district Rudarparyag/Chamoli etc.
- Fibre based products were developed from *Hibiscus cannabinus* (threatened bioresource of the region) for promoting its conservation and household level enterprise. The traditional uses & cost-benefit analysis of agronomic practices of *Hibiscus cannabinus* were also worked out.
- The capacity building programme has made significant contribution, which was reflected from the adoption of some of these technologies by the farmers into their farm, for example more than 53 progressive farmers of nine villages ( i.e., Sirsi, Rampur, Nyalsu, Badasu, Kimana, Josi, Majosi, Tosi & Triyuginarayan) have adopted low cost playhouse technologies and organic farming for off-season vegetable cultivation (Table-24, Fig.64 & 65) and more than 30 farmers adopted

**Table-24:** Enhancing income through protected cultivation of off-seasonal vegetables (Rs/yr)

| Villages | No. of household adopted protected cultivation (53) | Monetary equivalent (Rs) | | | Total monetary equivalent (Rs/yr) |
|---|---|---|---|---|---|
| | | Selling vegetable seedlings raised in nursery | Vegetable | | |
| | | | Own consumption | Sold in market | |
| Tosi | 07 | 44800.00 | 24000.00 | 9600.00 | 78400.00 |
| Triyuginaryan | 26 | 166400.00 | 76800.00 | 48000.00 | 291200.00 |
| Majosi | 03 | 19200.00 | 9600.00 | 4800.00 | 33600.00 |
| Kimana | 04 | 25600.00 | 9600.00 | 9600.00 | 44800.00 |
| Rampur | 02 | 13600.00 | 4800.00 | 4800.00 | 23200.00 |
| Sirsi | 11 | 70400.00 | 14400.00 | 38400.00 | 123200.00 |

* Off-season vegetable promoted for cultivation: Brinjal, cauliflower, cabbage, green peppers (simla mirch) etc. Average per family per year income: Rs 11215; Unit area under cultivation: 50 $m^2$

vermicomposting & biocomposting for maintaining organic cultivation. A small bioprospecting unit has been established for demonstration and processing of locally available bioresources. More than 165 families in eight villages of upper Kedar valley adopted value addition of wild edible bioresources which was considered economically highly beneficial.

**Fig.64.** Adoption of variety of off-seasonal vegetables at village Triyuginarayan.

**Fig.65.** Farmers are being provided live demonstration and training about raising low cost poly house technology in their own land.

## Establishment of Quality Assurance Laboratory for Medicinal Plants *(2009-2014, In-house)*

All over the world, plants play an important role in health care of majority of people. India has one of the richest and most diverse cultural traditions associated with the cultivation and use of medicinal plant. As per the traditional medicines program of the World Health Organization (WHO) nearly 80% of the world population use phyto-products, phytoconstituents produced by wild plants which play very important role in the livelihood of the rural communities. The task force report (2000) on "Conservation and Sustainable Uses of Medicinal Plants", Planning Commission Govt. of India, has clearly indicated that in recent years the interest on medicinal plants in the country has increased many folds. This realization has resulted into phenomenal increase of R&D in medicinal plant sector. The Indian Himalayan Region (IHR) due to its vastness and diverse climatic zones harbors a large number of plants of medicinal value.

Natural products mainly secondary metabolites, present in these medicinal plants, have always received a great deal of attention of chemists, enzymologists, biotechnologists as well as industrialist in recent times. These are the organic compounds that are formed by living systems. The elucidation of their structures and chemistry, synthesis and biosynthesis are major areas of organic chemistry. Our institute is already working on the ecological, biochemical and biotechnological aspects of these medicinal plants eg. *Aconitum balfourii, Podophyllum hexandrum*, *Picrorhiza kurrooa*, *Berberis* spp. etc. Except these *Taxus baccata, Ginkgo biloba*, *Rosa damascene* had also been studied.

Now there is need to develop full-fledged quality assured laboratory dedicated to phytochemical analysis. The main aim of establishing this facility is to centralize this in the institute so that it would be accessible to every researcher of institute as well as can provide service to outside agencies also.

### Objectives

- To establish quality assurance laboratory for medicinal plant analysis.
- To develop Chemical profile of selected Medicinal Plants initially from prioritized list of Uttarakhand.
- To provide hands-on-training and support in the Institute as well as outside agencies

### Achievements

- Details of cultivation of medicinal plants have been taken from Herbal Research & Development Institute, Gopeshwar (Uttarakhand) as well as from some local growers and NGOs. Amount of 7462 quintal medicinal plants were sold from cultivated sources during the year 2007-2008. Most of the plants are from prioritized list of medicinal plants. Facility for their Quality Assurance is required so that farmers will get better rate of their produce.
- Initially the work had been started with the extraction of medicinal plants like *Swertia aungustifolia* (anti

diabetic plant), *Vinca rosea* (anti cancerous plant), *Betula utilis* (anti cancerous plant). Further analysis (isolation, purification, identification would be carried out this year. This initial work is basically for standardizing the extraction step and for making Fundamental Standard operating Procedures (SOPs) which will help in further steps during analysis.

## Demonstration, value addition and up-gradation of traditional wild edible products for sustainable livelihood in Kedarnath valley of Uttarakhand *(2008-2011, DST, New Delhi)*

The recent increase in interest in potential wild bioresources including medicinally valuable plant species has been a consequence of a number of shifts in development focus. The increasing unemployment in the rural sector of upper Kedar valley is likely to have serious ramifications on socio-economic and environmental balance. In spite of numerous laudable developmental programmes and huge investments, the reality of rural livelihood in this region is rather dismal. There is a continuous distress migration to the semi-urban areas and cities and most of the villages lack the basic amenities and services. With the growing concern and commitment to hill area development and poverty alleviation has increasing interest in how untapped and underutilized wild edibles fruit, medicinal and aromatic plant and wild edible oil species can contribute to household's food and livelihood security. These resources are recognized and valued not only for their short term economic benefits, but also for their socio-cultural richness and the sustenance that they offer to large number of rural households.

### Objectives

- To undertake in-depth survey to assess the extent of area under some potential wild edibles species, MAPs and wild oil species across an altitudinal gradient of the Kedarnath valley, document indigenous knowledge and evaluate their contribution in local diet and traditional health care system.
- To undertake fruit yield assessment and phenological studies so as to provide appropriate time for fruit harvesting.
- To select the wild edible species, MAPs and wild edible oil yielding plant species depending upon the dominance and availability for local value addition and undertake cost benefit analysis of edible products developed from them.
- To develop skill and capacity building while providing timely and regular training to the target population and demonstrate the enterprise while preparing a variety of local value added edible products from selected wild edibles species, MAPs and wild oil yielding species which may be easily marketed.
- To explore the possibilities for establishing linkages between farmers/users and small scale industries for marketing and up gradation of the product made from different wild bioresources

### Achievements

- Assessment of extent of area under seven potential wild edible/ semi-domestic plant species, three medicinally valuable oil yielding plant species and five medicinal plants used as spice and condiments by traditional society were carried out in the study area.
- Documentation of indigenous knowledge regarding the use of these edible plant species in different traditional health care practices, diet and other uses were carried out (Fig.66).
- A small bioprospecting unit has been established for making various value added products from wild, domesticated and semi-domesticated edible plants/ crops at participatory rural technology centre at Triyuginarayan (Fig.67).
- Cost benefits analysis of juice/ squash and pickle preparation from different wild edible plant species has been carried out (Table-25).
- Two training programme has been organized in which 60 participants were provided training and live demonstration about value addition of wild edibles and agri-crops while making a variety of local value added products i.e. juice, squash, pickle, jam, sauce etc.

**Table-25:** Bioprospecting and cost-benefit analysis of various products prepared by local people for own consumption in a cluster of villages in upper Kedar valley.

| Wild bioresource | | No. of household prepared the product | Quantity of product prepared (Lit or kg) | Monetary equivalent (Rs) | Monetary equivalent (Rs/ family) |
|---|---|---|---|---|---|
| *Viburnum mullaha, Peonia emodi, Rhododendron arboretum, Emblica officinalis* | Juice/ Squash | 167 | 959.6 | 76768.00 | 459.6 |
| *Diplazium esculentum, Peonia emodi, Ficus auriculata, Emblica officinalis* | Pickle | 89 | 395.00 | 27650.00 | 310.74 |


**Fig.66.** Showing selected potential wild edibles of Kedarnath valley for value addition



**Fig.67.** Showing small processing units and products made of wild edibles at RTC, Triyuginarayan.

***Summary of Completed Project/Activity***

**Conservation and Sustainable Management of Belowground Biodiversity (BGBD) in Nanda Devi Biosphere Reserve** *(2005-2009, TSBF/GEF/UNEP)*

Socio-economic studies with reference to indigenous farmers' practices and knowledge on soil fertility maintenance and insect pest management in NDBR and adjoining areas were worked out. Macro faunal studies at three point of time (at two elevational gradients) in relation to abundance, biomass and species richness (earthworms, *Hymenoptera, Isoptera, Coleoptera, Myriapods, Dictyoptera, Diptera, Hemiptera, Orthoptera*) under different land uses/land cover types (alpine pasture, *Cedrus* forest, agricultural fields, oak forests, pine forests and degraded sites *etc.*) and causes of BGBD losses were carried out. Studies on assessment of biological nitrogen fixation of selected Himalayan legume crops in terms of Nitrogenase activity were undertaken under mono and mixed cropping.

Strategies and action plan for conservation and management of BGBD as a policy brief were developed. Abundance and diversity of vesicular mycorrhizal (VAM) fungi across a gradient of land use types. Assessment of abundance and diversity of legume nodulating (LNB) bacteria across a gradient of land use intensity. Peoples'/ farmers' response about indigenous knowledge on BGBD and related aspects particularly regarding beneficial and harmful insect/pests under different land uses. A study on socio-cultural, traditional ecological knowledge and ethno-medicinal properties and uses and agronomic practices of legumes crops was carried out. Assessment of anthropogenic pressure, traditional rights and natural resource management related issues were undertaken. Developed guideline, strategies and action plan for BGBD conservation and management of (NDBR)

***Summary of Completed Project/Activity***

**A study on prioritization and categorization of ailments specific medicinal plants and their contribution in traditional health care system of tribal and non–tribal communities of high altitude region of Alaknanda Catchment of Uttarakhand** *(2007-2010, National Medicinal Plants Board)*

The study has shown that the tribal and non-tribal communities of eight valleys (Niti, Urgam, Berahi,

Nandakini, Pinder, Mandakini, Bhilangana, Binser) of Alaknanda catchment possess immense traditional knowledge that use as many as 400 medicinal plants belonging to 115 families for curing 135 ailments through traditional health care system. After conducting in-depth study a total of 86 plant species and their indigenous uses for curing 37 major ailments were documented from eight valleys over a period of one year. This information was based on the detail investigation in the field as well as discussions with local healers, knowledgeable persons and medical doctors working in this region were carried out. Out of 400 medicinal plant species, 301 medicinal plant species were used for curing 97 ailments and were found common in all valleys. It was also noticed that about 320 plant species is used to cure more than one disease in various combinations whereas 39 plant species are used exclusively for curing skin diseases. A total 400 plants were checked and verified from the available literature and it revealed that the uses of 342 plants are listed in the Ayurveda whereas the uses of 58 plants are the new record. Among the medicinal plants (400) used in THCS, the root of the majority of the plants (27.9%) followed by leaves (25.2%), are used in curing a variety of diseases.

In addition to this, out of the total MAPs used, majority of them belonged to herbaceous community (56.9%) followed by trees (21.9%), shrubs (13.2%), Climber (6.8%), Creeper (0.6%) and Fungus (0.6%). Out of the total human population in all valleys, about 66.1% were found depending on herbal treatment practiced by local healers/Vaidyas and they also preferred it. A total of about 150 Vaidyas were consulted in detail through interactive discussions so as to reveal their perceptions on weakening and options for the development of traditional health care system. Three (3) workshop on "Traditional Health Care System and twenty (20) village level meetings were organized between April 2007 to March 2010 in which a total of 240 participants of which 150 were Vaidyas actively participated and shared their views and perceptions for improvement of THCS (Fig.68). A proposal from every participant came to form an association of the Vaidyas in Uttarakhand. Under the proposed name "*Paramparik Gramin Chikitsak Sabha (PGCS)"* association was formed and wasregistered under the registration act 21, 1860 from government registration office Gopeshwar, Chamoli, Uttarakhand. The project activities particularly awareness programme on T HCS got wide media coverage at local/regional level.

**Fig.68.** Organization of training programme for local Vaidyas and stakeholders for capacity building and awareness regarding traditional healthcare system.

## Theme

# R&D HIGHLIGHT OF THE REGIONAL UNITS

### GARHWAL UNIT

- The action and participatory research work carried out in the Unit in the various sectors is given due consideration by various line agencies at district and state levels and most of our findings has been incorporated in the action plan of MNREGA, GRAMYA, Horticultural mission, etc.
- Policy brief on Central Himalayan Agriculture" Hill agriculture of Uttarakhand: Policy, governance, research issues and development priorities for sustainability published in *The India Economy Review*, 2009, VI: 116-123 was highly praised and appreciated by policy and planners state and national levels.
- The capacity building programme has made significant contribution which was reflected based on the adoption of some of these technologies (i.e. 53 farmers adopted low cost polyhouse techniques and 165 household adopted value addition of wild edible bioresources) which has livelihood of the poor rural people to the large extent.
- Developed tourism/eco-tourism knowledge network involving different institutions working on eco-tourism/tourism related issues for knowledge sharing
- In-depth study on traditional health care system was carried out in high altitudinal region of Alaknanda catchment which revealed that about 400 plant species are being used by Vaidhyas or local healers for curing about 135 ailments. In addition, 150 Vaidhyas were consulted and interactive discussion was held with them to know their perceptions and attitude on weakening and possible option for the development of traditional healthcare system.
- Studies on traditional grain legume crops of the central Himalaya in relation to changes in temporal and spatial diversity, socio-cultural, traditional ecological knowledge, ethno-medicinal and neutraceutical properties, uses and agronomic practices were carried out.
- Inventory of macro and mesofauna in different landuses systems in Nanda Devi Biosphere Reserve were carried out under TSBF/GEF/UNEP project.

### HIMACHAL UNIT

- 22 plant communities were identified from 37 sites sampled between 1328-3488m from Nargu Wildlife Sanctuary (NWLS). Total tree density and total basal area, total shrub density, Species Diversity Index (H') for trees, saplings, seedlings, shrubs and herbs. Soil of each site was analyzed for pH, moisture content, nitrogen, organic matter and carbon. 62 species of economically important plants were recorded. Fuel extraction trend of the 15 villages assessed and analyzed for mean collection per house hold per day, mean collection per house hold per year, probability of use and resource use index. Fuel species prioritized for conservation based on the resource use index.
- Medicinal plants diversity (476 species) of the Chandra Valley Upper Beas Valley, Mohal Khad Watershed, Parbati Watershed and Upper Banjar Valley was assessed and analyzed for nativity and endemism. Populations of 17 threatened medicinal assessed and mapped.
- Diversity of economically important species in Chailchowk Rohanda Kamarunag Area (CRKA: 493spp.) and Hirb Shoja Catchments (HSCs: 445 spp.) was assessed and analyzed for utilization patterns as medicine, fuel wood, fodder, edible, timber, religious purpose, making agricultural tools and miscellaneous purposes. Extraction trends of fodder and fuel species in HSCs, CRKA and Shimla Ghannahatti Forests were assessed and analyzed for mean collection per house hold per day, mean collection per house hold per year, probability of use and resource use index. Fodder and fuel species are prioritized for conservation based on resource use index.
- Floristic diversity of the HSCs and CRKA was assessed for threat categories. 137 species under

Critically Endangered (28 spp.), Endangered (18 spp.), Vulnerable (37 spp.) and Near Threatened (54 spp.) categories in HSCs, and 118 species under Critically Endangered (16 spp.), Endangered (35 spp.), Vulnerable (67 spp.) and Near Threatened (40 spp.) in CRKA were categorized.

- Habitats and communities of CRKA were prioritized for conservation based on Conservation Priority Index (CPI). Amongst habitats, shady moist forest, dry forest, riverine and rocky habitats and amongst communities, *Abies pindrow, Pinus roxburghii*, *Picea smithiana, Quercus leucotrichophora*, *Pinus wallichiana* and *Cedrus deodara* communities were prioritized for conservation.

- Seed germination protocol for the *Cornus macrophylla* was developed. Germination results in polyhouse were better than that of the open condition. The treatments of $H_2SO_4$ 50% for 5 minutes and IBA 200µm showed maximum germination (55%) in polyhouse and treatment of IBA 200µm showed maximum germination (49%) in open condition.

- The Strategic Environmental Assessment (SEA) study in the Sutlej basin has shown a wide scope in systematic collection of baseline information in conducting EIA of individual hydropower project. Overlapping of the projects within an aerial distance of 10 km exists in either of the basins. In general, the local people were not satisfied with the existing mechanism of public hearing and overall environmental management practices being followed by the project proponents especially during construction. The status of environmental parameters has been adversely changed from pre construction stage to construction stage. Air, water quality and forests have mainly been among them.

- Solid waste study conducted in the 6 towns has shown dominating nature of biodegradable waste over non-biodegradables which ranged from 64.7% to 78.3% in Keylong and Mandi, respectively. There is a need to practice waste to energy initiatives in the form of bio-composting.

- The seasonal ambient air quality studies in a land campaign mode conducted in Bilaspur, Mandi and Keylong showed high concentration of particulate pollution compared to gaseous pollution. Many times, TSP and $PM_{10}$ have crossed their permissible limits as set by CPCB. On diurnal basis, highest concentrations of TSP and $PM_{10}$ were found between 16 hr IST to midnight followed by 8-16 hr and lowest between midnight to morning 8 hr throughout the season at each experimental site. The gaseous pollutants like $SO_2$, $NO_2$ and $NH_3$ were recorded far below the permissible limits.

- The ambient air quality parameters such as $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_2$ and $NH_3$ in the background sites of the hill spots at Kothi and Mohal were also monitored. The highest concentration of $PM_{10}$ at Kothi was 53.8±8.4 µg $m^{-3}$ during 8-16 hr in January 2010 and 86.03±7.3 µg $m^{-3}$ at Mohal during 16-0 hr in December 2009. However, $PM_{2.5}$ at Kothi reached 99±3.2 µg $m^{-3}$ during 0-8 hr in March 2009. $SO_2$ in maximum concentration at Kothi was 16.0±1.6 µg $m^{-3}$ during 0-8 hr in May 2009 and 7.7±0.5 µg $m^{-3}$ during 0-8 hr at Mohal in April 2009. $NO_2$ concentration at Kothi showed 5.7±0.7 µg $m^{-3}$ during 0-8 hr in April 2009. But this value at Mohal stood to be 8.2±1.3 µg $m^{-3}$ during 16-0 hr in June 2009.

- Aerosol Optical Depth, Black Carbon and Surface Ozone studies were carried out at Mohal. AOD change at 500 nm was found 54.7% from forenoon to afternoon. The variations in turbidity parameters; α and β were inversely proportionate. The BC monitored during July 2009 to March 2010 showed hourly mean value of 2500 ng $m^{-3}$ between 6 to 9 hr IST. However, the highest ever peak values remained 15657 ng $m^{-3}$ in January 2010 at 7 hr. Diurnal variation of $O_3$ showed low concentration during morning (8-9 hr) with a peak at afternoon (15 hr) which then starts to decrease gradually (18 hr - morning 8 hr). During observation period based on frequency distribution, hourly ozone concentrations remained 7 times above 50 ppb which causes harm to human as well as plant life.

- Morphological characteristics of fruits and stones such as their fresh weight, dry weight, length, width and moisture content of the Thalaut, Kolibehar, Kais and Saioond populations of *O. ferruginea* were determined. Mechanically scarified seeds of Thalaut, Kolibehar and Kais populations imbibed in distilled water for 24 hr were tested for germination at different temperatures (15-35$^{o}$C). Effect of rhizospheric soil on the stone germination of the three populations was studied. Stem cuttings collected from the selected populations during winter and summer seasons were treated with different concentrations (250-8000 ppm) of growth hormones namely IAA, IBA, NAA and 2, 4-D to determine the best population and season for vegetative propagation through stem cuttings. Shoot tips, nodal segments and leaf (middle portion) were

used as explants for the establishment of cultures. Microshoots were used to initiate rooting in them. Estimation of fat and fatty acid profile was done in the fruits and stones of the four populations.

- Quantum utilization of pesticides was reviewed. Pesticides distributed @ 12943 kg per year which ranged from 1463 (kg +L) - 24520 in 2007 and 2008, respectively. Among the pesticides, monocrotophos 36% SL, dimethoate 30% EC, cypermethrin 25%, 10% EC, endosulfan 35% EC, diclorvos 76%EC, chlorpyrifos 20%EC, mancozeb 75% WP, copper oxychloride 50% WP, copper sulphate, capton 50%SP, 2,4-D Na salt 80%, butachlor 50% EC, carbendazim 50%EC are used in cash crops such as apple, tomato, cauliflower and cabbage. The amounts and frequency of pesticide applications on these crops vary from 2.5 – 2.75 L $spray^{-1}$ $ha^{-1}$ and 1 - 20 times, respectively.

## SIKKIM UNIT

- World environment day (June 5, 2009) was observed at Pangthang by the GBPIHED-Sikkim Unit jointly with the Department of Forests, Environment and Wildlife Management Department (FEWMD), Govt. of Sikkim. The day-long programme was hosted at the Pangthang Junior High School premises with focus on slogan of the year – "Save the planet earth – unite to combat global warming". A large number of high quality, tissue culture and nursery raised, rare and threatened rhododendron spp, developed by GBPIHED were planted with active participation of the local folk, especially village women, personnel from the Forest Department and GBPIHED. Shri Bhim Dhungyal, Hon'ble Minister FEWMD and Mr. S.T. Lachungpa, the Principal Chief Conservator of Forests-cum-Secretary, Government of Sikkim also attended and graced this event.
- Landslide inventory of east district completed.
- Identification of installation location of 3 automatic weather station in Pangthang, Lachen and Ravangla. Installation of instrument is in process.
- Organized a Training Program on Formulation of District Disaster Management Plan for Senior to middle level officers of line departments of Govt. of Sikkim jointly with National Institute of Disaster Management, New Delhi & Land Revenue and Disaster Management Department, Govt. of Sikkim.
- Organized Training on Concept of Natural Disaster and Disaster Management to Student and Teacher of Panthang Senior Secondary School, Tadong, East Sikkim. Nav Yug Public School, Ranka and Rumtek.
- Organized Training on Village disaster management plan at Namchi, Sakyong, Mazitar and Gairigaon.
- Landslide mitigation in Bojeck landslide.
- Delineated glaciated area of Teesta river basin in Sikkim.
- Resource person for SAARC training on Bioengineering methods for landslide hazard mitigation. Kwopa Engineering Collage, Bhaktapur, Kathmandu, Nepal. Organised by Disaster Management Cell, SAARC Centre, New Delhi. 6th September, 2009.
- Data on tourist influx to Sikkim for the period 1980 to 2009 was synthesized for analyses of inflow trend-patterns, trend projections and its likely implications for infrastructure, environment and demand-supply systems.

## NORTH EAST UNIT

- During the reporting period two major programmes, i.e., Nagaland Environment Protection and Economic Development (NEPED) and North Eastern Region Community Resource Management Project (NERCRMP) and five Acts, i.e., (1). Balipara/Sadiya/Tirap Frontier Tract Jhum Regulation Act, 1947, (2). Arunachal Pradesh Anchal Forest Reserve Act, 1975, (3). Arunachal Pradesh Forest (Removal of Timber) Regulation Act, 1983, (4). Assam Forest Regulation, 1891, and (5). Forest (conservation) Act, 1980 relating to shifting agriculture were reviewed.
- The customary practices with focus on festivals, rituals and rites linked with shifting agriculture have been documented.
- Twenty two (22) Biodiversity Management Committees (BMCs) have been constituted in Tawang-West Kameng BR (proposed) and in Apatani plateau in Arunachal Pradesh under GOI-UNDP CCF-II project for conserving and sustainably managing the bioresources.
- Nearly 5000 hectares of *Mihin-Radhe* community forest in Apatani plateau have been brought under Community Conserve Area (CCA). *Tajang Rantee Sacred Grove*, a forest patch of three villages (Moilyang, Lempia and Tajang) in Apatani plateau in Arunachal Pradesh has been strengthened through GOI-UNDP CCF-II project.
- Three high altitude nurseries have been developed for propagation of *Taxus wallichiana, Swertia chirayata* and multi-purpose tree species. Approximately 30,000

*Taxus wallichiana* saplings have been propagated in the High Altitude Nursery at Ziro Plateau in Arunachal Pradesh. Plantation of horticultural crops have been initiated by bringing 6.25 and 8.55 ha of land area under kiwi (*Actinidia deliciosa* ) and large cardamom (*Amomum subulatum)* plantation, respectively. Income generation activities (IGAs) are carried out by providing piglets to 60 families in Apatani Plateau.

- Under a contract signed with IUCN, the NE Unit completed Red List Assessment of 83 freshwater fish species found in Eastern Himalaya.
- The catch frequency assessment of fish species for commercial production in hill stream fishery was carried out in the Senkhi stream, Arunachal Pradesh. The catch frequency yield revealed that the *Barilius bendelesis* has catch frequency of 100%, followed by *Aborichthys elongatus* and *Psilorhynchus balitora* at 93% suggesting that *Barilius bendelesis* is most suitable species for commercial production in hill stream fishery.
- Under response assessment and processing of knowledge base to serve long term management and use of biodiversity in the Himalaya, survey carried out in Tawang-West Kameng BR (proposed) in Arunachal Pradesh documented a number of plants species belonging to angiosperm (296 spp.), gymnosperms (12 spp.), and pteridophytes (7spp.), lichens (11 spp.).
- Role of religious institutions like Gompa (Monastery) in conservation of species and deities enhancing to conservation that are being worshiped or believed by Monpa and Sherdukpen tribal communities in Tawang-West Kamnrg mega cultural landscape have been documented through UNESCO-McArthur project on cultural landscape. A total of 24 plant species were identified, which were being ranked higher in cultural and traditional belief system of the communities and most of these plants are conserved due to their religious, economic and medicinal values.
- The cultural calendars corresponding to the agricultural calendars of the Monpa and Sherdukpen communities were documented along with the various belief systems, rituals, traditional dances, food items and food habits and art & crafts involving festivals.
- Listing of faunal species following IUCN categories is carried out. Major endangered species found in the Tawang-West Kamnrg mega cultural landscape are Snow leopard (*Unicia unicia*), Musk deer (*Moschus moschiferus)*, Common leopard (*Panthera paruds),* Tiger (*Panthera tigris)*, Asiatic black bear (*Urasus thibetanus)*, Arunachal macaque *(Macaca munzala)*, Capped langur (*Trachypithecus pileatus)* and Himalayan goral *(Naemorhedus goral).*

## Theme

# APPLICATION OF R & D OUTPUTS IN DEMONSTRATION AND DISSEMINATION

### Field evaluation of microbial inoculants developed for use in mountains *(2007-2010, UCOST)*

In order to develop microbial inoculants for use in the colder regions of mountains, a long term study was conducted in the Institute. At the very outset, field inoculation trials were carried out at higher elevations using available microbial inoculants. The study confirmed effectiveness of microbial inoculants only at the lower elevations, and indicated that there was a need of isolation, screening and selection of native microorganisms, originally from higher elevations, that could be developed in the form of microbial inoculants specifically for colder regions of mountains. The present project was developed for field evaluation of the mountain specific microbial inoculants, in collaboration with local people.

#### Objectives

- Field testing of the carrier based microbial inoculants using important agricultural and forest species of mountains, and
- Creating awareness to the local farmers about this ecofriendly microbe-based technology through on-farm demonstrations.

#### Achievements

- Microbial inoculation trials have been conducted on selected agricultural and forest species in nursery, farmers' plots and in net house in three consecutive years. While an increase in biomass and yield of the agricultural and forest species was observed, increase in chlorophyll in leaves, leg-hemoglobin in nodules and protein content in various plant parts was also recorded. Microbial analysis revealed the stimulation of native beneficial microflora and suppression of pathogenic fungi.
- The villagers showed a positive attitude to adopt this inexpensive and ecofriendly microbe based technology in integration with the traditional use of organic inputs and water management.

### Capacity development and economic upliftment of rural women through pond based integrated farming system approach *(2007-2010, DST -Women Scientist Scheme)*

Agriculture is vital for livelihood and sustenance of hill economy. An overwhelming majority of the working population, mainly women in Uttarakhand are engaged in agriculture and allied activities, merely due to lack of alternative sources for employment and income generation. Nevertheless, traditional agriculture being practiced is not capable of sustaining them at a satisfactory level. Small, subdivided and fragmented land holdings, declining soil fertility, absence of irrigation facilities and non adoption of improved crop varieties and technologies are important factors accounting for low agricultural productivity in the region. Non-profitable nature of agriculture is the main reason behind low level of education, unemployment, malnutrition and associated health problems, particularly among women, back bone of hill agriculture. Women are unaware of technologies suitable for their region and potential supplementary resources for income generation. There are limited possibilities of increasing area under cultivation. Therefore, intensive use of the available land, water and human resource is imperative. Under such circumstances, to make most farming activities economically viable and ecologically sustainable, it is necessary to evolve new concept of Integrated Farming System (IFS), which emphasizes judicious combination of two or more farming activities, which are complementary to each other, facilitating effective recycling of resources within the system. Creation of appropriate model (s) and rigorous testing of such models for their validation and improvement under specific environmental conditions is the key to the success of the approach.

#### Objectives

- To optimize utilization of water, under used land resources and farm waste (biomass) through integration of fishery with poultry/duckery livestock,

vegetable and mushroom cultivation, green fodder production and biocomposting/vermicomposting.

- To provide employment, income generation opportunities and nutritional security to rural folk.
- Motivation and capacity building.
- To determine seasonal changes in physico-chemical and microbiological parameters of water, fish diseases, vegetable diseases and their management.
- Documentation of success stories.

### Achievements

- Integrated Farming System (IFS) model has been evolved for the first time in hills of Uttarakhand and investigations on IFS were carried out for its validation in the hilly region.
- IFS model comprising various complimentary components such as composite carp culture, poultry, vegetable, mushroom, fodder production and vermicomposting have been completed at village Patherkote (1420 m amsl) in Hawalbagh block during (2009-2010).
- Fingerlings of exotic carps (3000/ha) and chick birds, Kuroiler (3000/ha) were stocked at two sites, i.e., Sunaulla (1200 m; created during 2008-2009) and Patherkote.
- Substantial survival of fingerlings (71.0-85.5%), chick birds (86.7%) and their subsequent growth was recorded. Fingerlings attained average weight of 280-475 g, while chick birds grew to1.5-2.75 kg within rearing period of 8 months at village Sunaulla.
- Around one ton different vegetables were produced on land around the fish pond, exploiting overflow of pond for irrigation and utilizing vermicomposting produced in the model; 41.7% of these vegetables were consumed, while the rest generated Rs 5794.00 by its sale following the model at Sunaulla village. Root rot, damping-off of seedlings, leaf blight and powdery mildews were observed on these crops with varying severity. Occurrence of powdery mildew on summer squash and pea, late blight on potato and tomato, and purple blotch on onion was reported high during the year.
- Nearly 850 kg compost was obtained from two beds (8.0'x2.5'x1.0') within a year, using the efficient species of earthworm, *Eisenia foetida*.
- Net gain of Rs 21,187 was obtained in a year with investment of Rs 10,286 by the beneficiary farmer. Besides, IFS provided employment, food and nutritional security to the farmers' family.
- Water temperature (10.3-31.7°C), pH (6.9-8.1), DO (4.9-8.2mg/l) and conductivity (69.9-140.7 mohs) during fish rearing period were well within the range for normal growth of fish at village Sunaulla.
- Altogether, 26 species of extra-aquatic fungi and 17 species of watermolds, including virulent pathogens of crops (species of *Alternaria, Fusarium* and *Pythium*) and fish (*Saprolegnia* and *Achlya*) were isolated from pond water at village Sunaulla.
- In all, capacity of 419 persons including 112 women was strengthened through lectures, audio-visual aids and field visits. Twenty two farmers were trained on IFS at a demonstration site.

## Enhancement of Livelihood Security through Sustainable Farming Systems and Related Farm Enterprises in North-West Himalaya *(2007-2012, NAIP-ICAR)*

The challenge of long-term sustenance of growth has been highlighted by several recent studies that found the total factor productivity (TFP) in agriculture declining between the 1980s and 1990s. The green revolution in wheat and rice, white revolution in milk, yellow revolution in oilseed and the blue revolution in fisheries have augmented the food basket of the country. But many technological challenges remain. To address these challenges and to generate additional income and employment for the poor, the role of agricultural research and development is critical. Given the limited scope for area expansion, increases in productivity, profitability and competitiveness will have to be the main parameters of the agricultural growth in the future and this should be led or triggered by advances and innovations in, and applications of science in agriculture. In other words, Indian agriculture will have to shift from resource or input-based growth to knowledge or science-based growth. Integrated farming system approach for improved livelihood through community based natural resources management has been identified for execution of the present project. Strengthening of interrelationship between different components of the hill farming system and dependency of the villagers on the natural resources have been taken in to consideration. The main emphasis in this component is given to improving the sustainability of the farming systems and natural resource management in less favorable environments. Particular attention has been given to rain-fed agriculture, common lands and waste lands of the Champawat and Tehri districts of Uttarakhand.

### Objectives

- Enhancement in the agricultural productivity and profitability through proven technological interventions.

- Up-gradation and management of natural resource base.
- Agro-processing, value addition and improved marketing for enhancing profitability and employment opportunities.
- Empowerment through capacity building and skill development in core and allied agricultural sectors along with employment generation.

## Achievements

- Common lands under the management of Van-Panchayat through vegetation rehabilitation and establishment of different tested prototypes have been identified to address the scarcity of fuel wood, fodder, increasing soil erosion and associated environmental degradation in identified village clusters of Champawat and Tehri districts of Uttarakhand.
- Three village clusters namely Dharaonj, Banlekh-Muriyani and Makot-Churani have been identified in Champawat district, whereas Jaminikhal, Manjgaon and Hadiya clusters were identified in Tehri district. The major problems with regards to the natural resources have been identified through surveys, meetings and discussions.
- Stakeholders consultation and need based assessment was made through meetings and discussions. Similar practice was followed for species prioritization, participation and knowledge sharing.
- House hold survey on various domestic energy requirements, fuel and fodder scenario, etc. in different establishments shows a huge difference between demand and supply of fuel wood and fodder. Based on the preliminary results, tested prototypes have been established through adopting community based natural resources management approach.
- Apart from the long term benefit ensuring activities (rehabilitation of degraded lands) short term benefit ensuring activities like cultivation of medicinal and aromatic plant species (Fig. 69a & 69b) and floriculture have also been initiated (Fig. 70a & 70b).
- Harvesting and storage of water, soil/water conservation practices and mass scale cultivation of improved grasses have been initiated in degraded as well as terrace bunds of agricultural land.

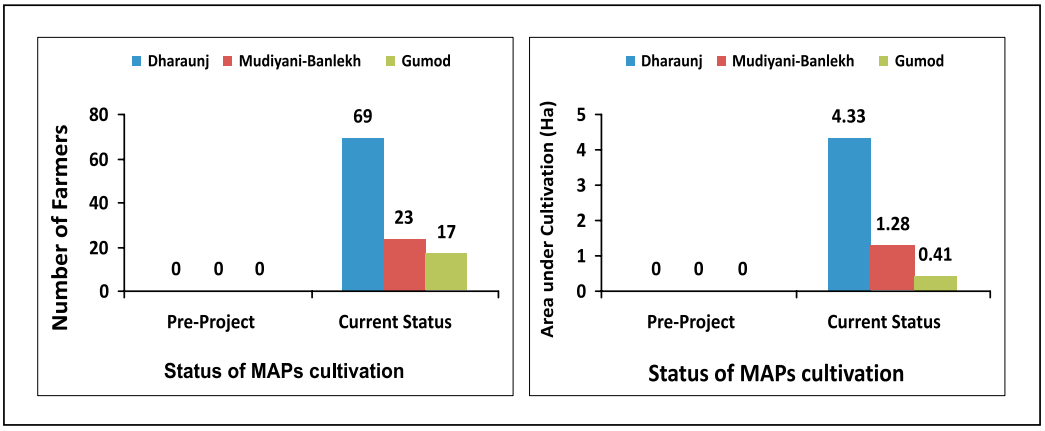



**Fig. 69a.** Status of cultivation of MAPs (number of farmers)

**Fig. 69b.** Status of cultivation of MAPs (area under cultivation)

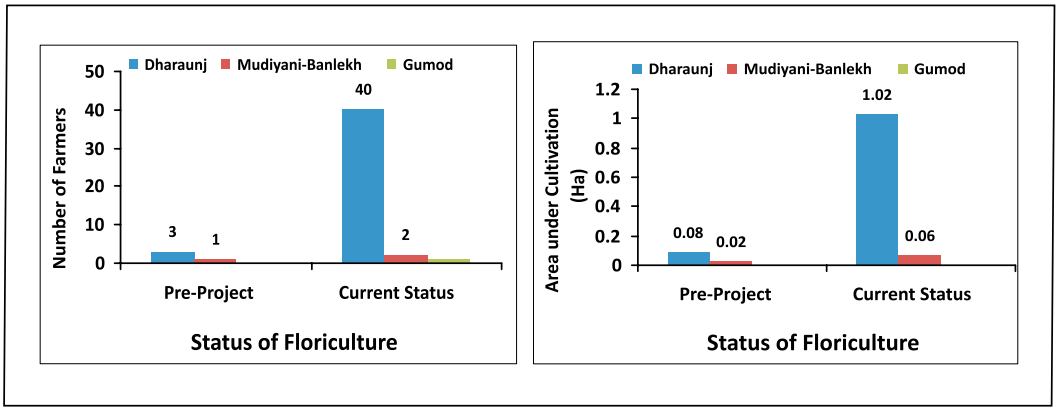



**Fig. 70a.** Status of cultivation of floriculture (number of farmers)

**Fig. 70b.** Status of cultivation of floriculture (area under cultivation)

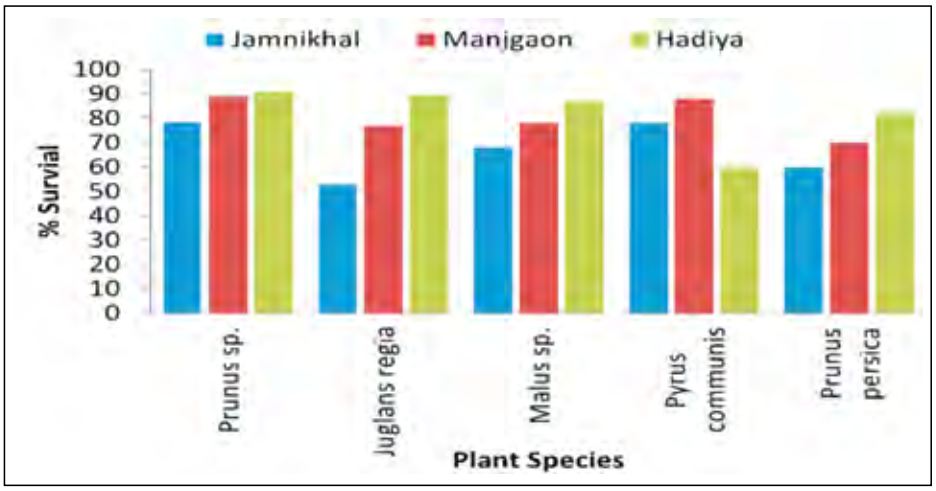



**Fig. 71.** Survival % of Horticulture plants

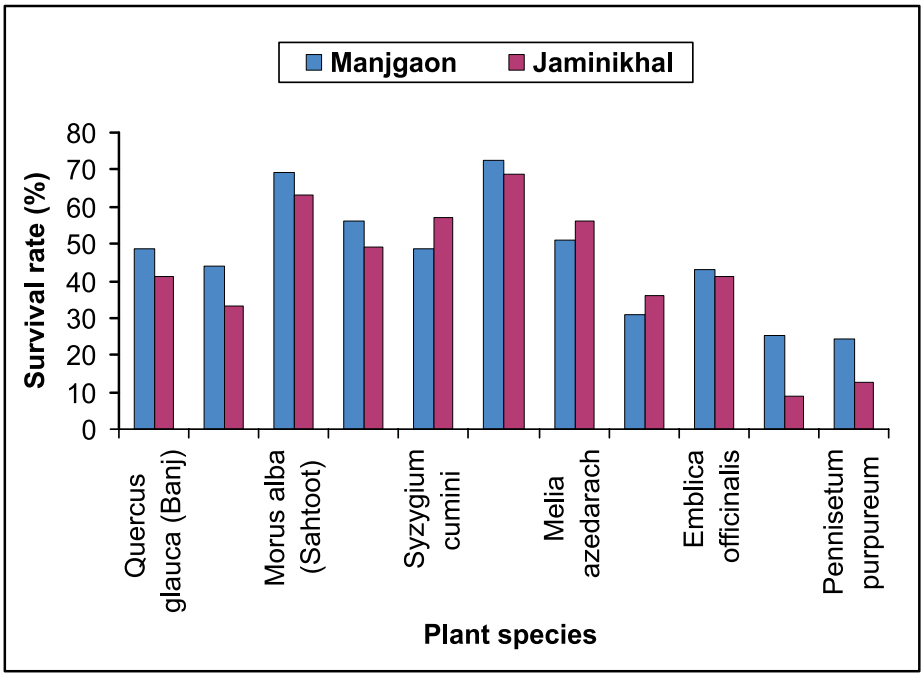



**Fig. 72.** Survival % of MPTs

- Under horticulture model results illustrated that there was slightly decline in seedling survival of 4.44% for *Prunus armenica* in Hadiya followed by Jamnikhal (9.10%) and Manjgaon (9.30%). On the other hand the decline in survival % of *Juglans regia* was found maximum of 24.40% in Hadiya cluster followed by Jamnikhal (16.47%) and Manjgaon (11.67%) (Fig. 71).
- Under MPTs model results illustrated that the *Sapundus* species showed the maximum survival of (72.3%) followed by *Morus alba* (69.1%), *Bauhinia purpuria* (56.2%), *Melia azedarach (*51.2%), *Syzygium cumini* (48.6) and *Quaercus glauca* (48.5) at different village clusters (Fig. 72).

### Integrated Eco-development Research Programme (IERP) in the Indian Himalayan region *(1992 – Long Term scheme, MoEF, Govt. of India)*

Ministry of Environment and Forests (MoEF), Government of India entrusted the responsibility of Integrated Action Oriented Research, Development and Extension Programme (termed as Integrated Eco-development Research Programme - IERP) in the Indian Himalayan region (IHR) to the Institute in 1992. The Institute funded R&D projects under two broad thrust areas [namely, Technology Development and Research (TDR) for Integrated Eco-development, and Technology Demonstration and Extension (TDE)] up to 2006-2007.

After that, location-specific/action-oriented R&D projects are being funded under the IERP within 6 identified themes [namely, Watershed Processes and Management (WPM), Biodiversity Conservation and Management (BCM), Environmental Assessment and Management (EAM), Socio Economic Development (SED), Biotechnological Applications (BTA), and Knowledge Products and Capacity Building (KCB)] of the Institute.

### Objectives

- To provide extra mural funds to different Universities/ Institutions / NGOs / Voluntary agencies for the support of location-specific R&D activities in the Indian Himalayan region (IHR).
- To develop scientific capabilities in the IHR and strengthen infrastructure for environmental research.
- To develop and execute coordinated programmes as per R&D need(s) of the IHR or on the recommendations of the completed projects with the help of identified network partners.

### Achievements

- Based on the recommendations of the 15th PEC, 16 projects (3 under WPM theme, 9 under BCM theme and 4 under SED theme) were sanctioned for execution in 5 States (namely, Himachal Pradesh, Uttarakhand, J&K, Nagaland and Assam) of the IHR.
- Funds for 42 ongoing/completed projects were released to different organizations after careful examination of the Utilization Certificates (UCs) and Statement of Expenditures (SEs).
- Annual Progress Reports (APRs) of 20 on-going projects were processed and referred to the subject experts for evaluation. Subsequently, the comments of the subject experts on the APRs were sent to the concerned PIs for follow-up action.
- Final Technical Reports (FTRs) of 15 completed projects were sent to various govt./user agencies for follow-up action on the recommendations of the project and also to the subject experts for their comments/suggestions.
- Coordinated programme entitled "*Sacred values, eco-restoration and conservation initiatives in the Indian Himalayan region*" was continued and strengthened in 3 States (namely, Uttarakhand, Himachal Pradesh and Meghalaya) of the IHR.
- Follow-up action on 188 project files (old/fresh/ on-going/miscellaneous, etc.), excluding routine correspondences of about 770, was also initiated/ completed during the year.
- Thirty seven R&D projects were on-going in 4 States (namely, Himachal Pradesh, J&K, Manipur and Uttarakhand) of the IHR under the IERP of the Institute.
- Strengthening and continuation of 37 location-specific R&D projects in different States of the Indian region under the IERP of the Institute.

## Strengthening and Management of ENVIS Centre in the Institute *(1992 – Long Term Scheme, MoEF, Govt. of India)*

Environmental Information System (ENVIS) Centre on Himalayan Ecology was set up in the Institute in 1992 as a part of ENVIS network in India by the Ministry of Environment and Forests (MoEF), Govt. of India; the nodal agency in the country for collecting and collating all available information from all the ENVIS Centres to provide national scenarios to the international set up, INFOTERRA Programme, of the UNEP.

### Objectives

- To collect, collate, compile and build qualitative and quantitative databases of information related to various aspects of Himalayan Ecology.
- To disseminate all available information, free of cost, to various stakeholders/users including all the District Information Centres (operating in the Himalayan states of the country), ENVIS Centres/Nodes and other user agencies/groups, through print and electronic media.
- To develop, up-grade and maintain ENVIS website at the headquarters of the Institute.

### Achievements

- Information on various aspects of Himalayan Ecology from various District Information Centres, Universities/ University Campuses, Research Centers, Government Institutions, NGOs and experts/individuals working in the Indian Himalayan region (IHR) were collected and compiled during the year.
- Research abstracts/articles/technical reports and news-clippings on Himalayan environment related issues were collected from various sources. The abstracts and news-clippings (bi-lingual) were published in the 'Selected Abstracts' and 'News and Views' section of the ENVIS Bulletin.
- About 24 research abstracts, related to the various aspects of Himalayan Ecology, were collected and

added on the Abstract Database of the ENVIS Centre. At present, this database contains 1939 abstracts.

- Website of the ENVIS Centre on Himalayan Ecology <http://gbpihed.gov.in/envis/envis.html> was re-designed, maintained and upgraded at the headquarters of the Institute (GBPIHED).
- Searchable databases of all the research abstracts, which have been published so far in the ENVIS Bulletins of the Centre; of all the published research papers/articles, which have been appeared/included so far in the ENVIS Bulletins of the Centre; of medicinal plants of the Indian Himalayan region (IHR); of news-clippings on Himalayan environment related issues, which were published in different newspapers; and, of Ph.D. theses (related to environmental sciences), which were awarded by various universities, were developed during the year 2009-10.
- 'Query Response Form' was designed and uploaded in the website of the ENVIS Centre.
- All the publications of the ENVIS Centre, such as - ENVIS Bulletins, ENVIS Monographs and ENVIS Newsletters, which were published so far, were uploaded (in PDF format) in the website of the ENVIS Centre.
- About 108 queries, related to Himalayan environment and development, were responded to the individuals/ institutions during the year 2009.
- All available information on various aspects of Himalayan Ecology, which were collected and compiled during the year, were disseminated to 481 stakeholders through electronic and print media.
- ENVIS Bulletin (Volume 17) and ENVIS Newsletter (Volume 6) on Himalayan Ecology were prepared, published and made online through the website of the ENVIS Centre.
- Efforts for the conversion of ENVIS website from its STATIC mode to DYNAMIC mode were carried out during the year 2009-10.
- Online availability of all the ENVIS documents (17 Bulletins, 3 Monographs and 6 Newsletters) on the website of the ENVIS Centre <http://gbpihed.gov.in/envis/envis.html>.

## Central Library Facility

The Central Library of the Institute at its headquarters, at the end of financial year 2009-2010, had 14,574 books. The library is subscribing a total of 107 periodicals (69 Foreign and 38 Indian). For management of Library and Information Centre, a network version of the software PALMS developed by the Scientist of this Institute is being used. As a result, the Library is providing a number of services such as Article Alert, Current Awareness, Selective Dissemination of Information, Reprography, Reference, Indexing, Bibliography, Web Services (Online Journals) etc., for the development of the human resources. The Library of the Institute is accessible through the Institute's web site (http://gbpihed.gov.in).

During the reporting year, 214 new book titles were added to the Library. R & D achievements of the Institute were disseminated through its regular in-house publications, namely Hima-Paryavaran–a biannual newsletter and Institute Annual Report to various academic and scientific institutions, Government departments, NGOs, policymakers, planners and individuals working on various aspects of mountain environment and development.

## Strengthening & Management of IT Infrastructure

Institute has two backbone networks, one is from NIC, New Delhi (NICNET network) which provides 128 kbps shared (HQs and Units) bandwidth for internet access and other is from BSNL-HUB, Bangalore which provides 512 kbps shared (HQs, Units and MoEF) bandwidth through VSATs for video conferencing & internet access. The bandwidth is distributed within the Institute HQs & Units through Local Area Network (LAN). The Institute website has been developed and hosted at the Internet Data Centre (IDC) of NIC, New Delhi. The URL of the Institute website is *http://gbpihed.gov.in*. A VPN (Virtual Private Network) has been created on NICNET for remote web site updation at Institute's end. The website of the institute has been updated at frequent intervals. Strengthening of Wide Area Network (WAN) for Video Conferencing & Internet facility in the Institute was also completed. The Institute is now having video conferencing with units & arranging live telecast of Annual day function and various other programmes through video conferencing service to Units. A database of Scientific/Technical and Research Scholars has been developed and uploaded on the Institute website. The official e-mail accounts on NIC mail server (mail.nic.in) have been created and provided to all Scientists, Technicians, Finance and Administrative staff.

## Central Laboratory Facility

Institute has strengthened the facilities of physico-chemical, biological, heavy metal analysis of drinking, raw, waste water and quantification of volatile compounds of soil and plant samples. The heavy metals in the water and soil samples are detected through Atomic Absorption Spectrophotometer (Make- Varian AA280Z, equipped

with graphite tube atomizer). For the quantification of aromatic and volatile compounds institute have Gas Chromatography (make- Chemito, Ceres 800+). Institute is also having the facility of detection of C, H, N & S through CHNS-O analyzer (make- Elementar, Vario EL-*III*) and UV-Vis spectrophotometer (make- UV 5704, Electronics corporation of India Ltd.) for soil, water & plant analysis. The Institute has extended these services for other organizations (NGO's and other Government Organization) on payment basis. In the financial year 2009-10, Institute has collected 4.065 lakh rupees as a central laboratory service charge from 60 organizations (21 - Govt. organization & 39 - NGO's). Fig.73 shows month wise collection of testing charges and service offered to different other organizations.

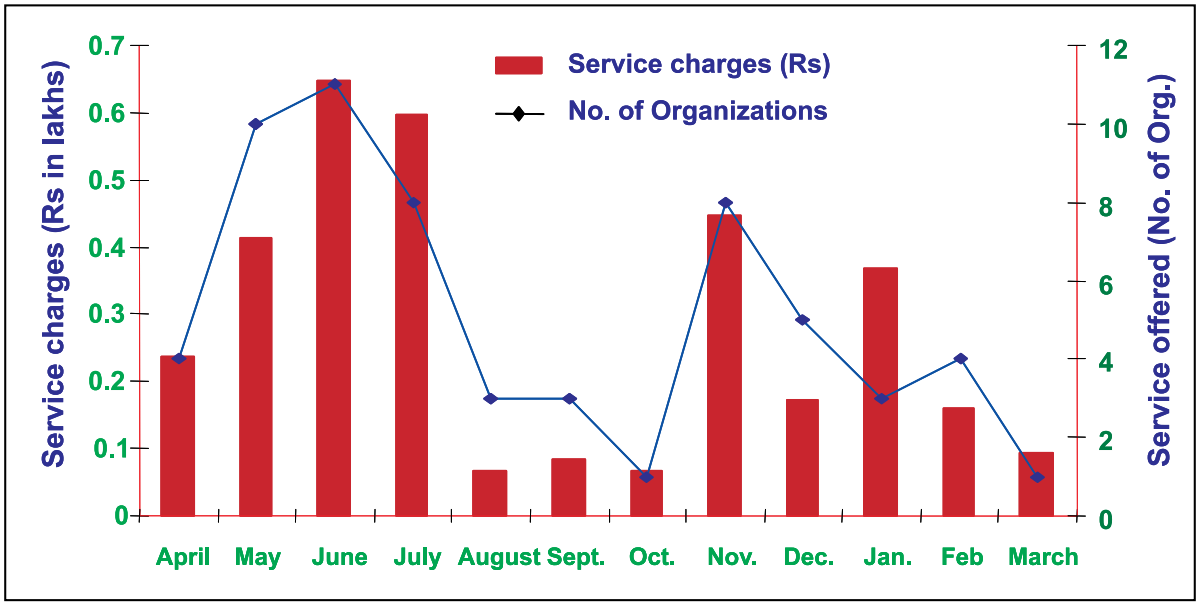



**Fig.73.** Graphic representation showing total charge fee collected from Central Laboratory Services in 2009-10.

# MISCELLANEOUS ITEMS

## 1. SCIENTIFIC PUBLICATIONS

### (I) Scientific Journals

Agnihotri, R.K., J. Mishra and **S.K. Nandi** (2009) Improved in vitro shoot multiplication and rooting of *Dendrocalamus hamiltonii* Nees et Arn. Ex Munro: Production of genetically uniform plants and field evaluation. *Acta Physiologiae Plantarum* 31: 961-967.

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## 2. AWARDS AND HONOURS

Bharat Excellence Award for outstanding contribution in the field of environment and human resource development; conferred by Dr. G.V.G. Krishnamurti on 20 October 2009 (**Dr. P.P. Dhyani**).

Gold Medal of the Indian Academy of Environmental Sciences (IAES) for outstanding contribution in the field of mountain ecology and environmental sciences; conferred by Professor Swatantra Kumar on 19th February 2010 (**Dr. P.P. Dhyani**).

Young Soil Conservationist Award-2008, for outstanding contributions in the field of Soil Microbiology - conferred by Indian Association of Soil & Water Conservationists at Agra, 2009 (**Dr. Paromita Ghosh**).

Recipient of Miss Rambha Khetwal Memorial Trust Award, Bageshwar, Uttarakhand for Outstanding Contribution to Research & Development (**Dr. S. K Nandi**)

Leading Scientists of the World-2009 awards by the International Biographical Centre, Cambridge, England (**Dr. S.C. Joshi**).

Selected as one of the IBC's top 100 scientists-2010 (**Dr. S.C. Joshi**).

## 3. PATENT

Khanuja, S.P., S. Paul, A. K. Shasany, A. K. Gupta, M.P. Darokar, A.K Shukla, M.M. Gupta, A.Kumar (2009). Primers and a screening method for identification of artemisinin producing plants. US Patent No: 7,473,768 (for work done at CIMAP, Lucknow)

## Participation of Institute Faculty/Project Staff in Different Events:

| Events | HQs | Units | | | | Total |
|---|---|---|---|---|---|---|
| | | NE | Sikkim | Garhwal | HP | |
| ***National*** | | | | | | |
| • Symposia / Conferences / Workshops | 50 | 26 | 16 | 09 | 15 | **115** |
| • Training Courses | 22 | 06 | 19 | 05 | 24 | **76** |
| • Meetings | 49 | 15 | 30 | 07 | 30 | **131** |
| • Participation as a Resource Person | 44 | 05 | 34 | 05 | 28 | **116** |
| • Any Other | 12 | 06 | 19 | 01 | 24 | **62** |
| ***International*** | 09 | 07 | 06 | 01 | 02 | **25** |

**ANSUL AGRAWAL & CO.**
Chartered Accountants
Sela Khola, Chaughan Pata, Near P.W.D. Office, Almora – 263 601 (Uttarakhand)
Tel.: 05962-230158, 232158, Fax: 05962-231030, Mobile: 94101-83805, 098101-53504
E-mail: ansulagrawal@rediffmail.com

**To**
**Members,**
**G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT,**
**NEW DELHI.**

We have audited the attached Balance Sheet of **G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT (A Institute of Govind Ballabh Pant Himalaya Paryavaran Evam Vikas Sansthan)** which are in agreement with the books of accounts, maintained by the Institute as on 31st MARCH, 2010. We have obtained all the information & explanations, which to the best of our knowledge and belief were necessary for the purpose of audit. In our opinion, proper books of accounts, as required by the law have been kept by the Head Office and the Units of the above named Institute, so far as it appears from our examination of the books. Proper returns adequate for the purpose of audit have been received from Units not visited by us, subject to the Notes on Accounts and comments given below:

As per notes on accounts\observations

In our opinion, and to the best of our information and according to the explanations given to us and subject to the notes forming part of accounts the said accounts give the true and fair view:

i) In the case of Balance Sheet of the State of Affairs of the above named Institute as on 31st MARCH, 2010 and
ii) In the case of Income & Expenditure accounts of the INCOME of its accounting year ending 31st MARCH, 2010.

**FOR ANSUL AGRAWAL & Company**
**CHARTERED ACCOUNTANTS**

**Sd/-**

**C.A. ANSUL AGRAWAL** **SEAL**
**(PARTNER)**

**DATED: 23.08.2010**
**PLACE: ALMORA**



Branch Office: 3/37, First Floor, Main Shivalik Road, Malviya Nagar, New Delhi – 110 017
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# G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
# KATARMAL, KOSI ( ALMORA ) Uttarakhand

## BALANCE SHEET AS ON 31st MARCH, 2010

| PARTICULARS | SCHEDULE | CURRENT YEAR | PREVIOUS YEAR |
|---|---|---|---|
| CORPUS / CAPITAL FUND | **1** | 54154882.92 | 47528301.92 |
| RESERVE AND SURPLUS | **2** | 405665244.81 | 391723534.08 |
| EARMARKED / ENDOWMENT FUNDS | **3** | 0.00 | 0.00 |
| SECURED LOANS & BORROWINGS | **4** | 0.00 | 0.00 |
| UNSECURED LOANS & BORROWINGS | **5** | 0.00 | 0.00 |
| DEFERRED CREDIT LIABILITIES | **6** | 0.00 | 0.00 |
| CURRENT LIABILITIES AND PROVISIONS | **7** | 59013786.08 | 66510802.39 |
| **T O T A L** | | **518833913.81** | **505762638.39** |
| **ASSETS** | | | |
| FIXED ASSETS | **8** | 405665244.81 | 391723534.08 |
| INVEST. FROM EARMARKED/ENDOWMENT FUND | **9** | 29396720.48 | 26920216.48 |
| INVEST. OTHERS | **10** | 0.00 | 0.00 |
| CURRENT ASSETS, LOANS, ADVANCES ETC. | **11** | 83771948.52 | 87118887.83 |
| MISCELLANEOUS EXPENDITURE | | | |
| **T O T A L** | | **518833913.81** | **505762638.39** |
| SIGNIFICANT ACCOUNTING POLICIES | **24** | | |
| CONTINGENT LIABILITIES & NOTES ON ACCOUNTS | **25** | **0.00** | |

**AUDITOR'S REPORT**
**As per our separate report of even date annexed.**
**FOR: ANSUL AGRAWAL & CO.**
**CHARTERED ACCOUNTANTS**

**Sd/-**
(DR. L.M.S. PALNI)
**DIRECTOR**

**Sd/-**
**(CA. ANSUL AGRAWAL )**
**PARTNER**
**M No.** 092048

**Sd/-**
(Dr. S.C.R. Vishvakarma)
**D.D.O**

**DATED: 23.08.2010**
**PLACE: ALMORA**

**Sd/-**
(K.K. Pande)
**Finance Officer**

**SEAL**

# G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
## KATARMAL, KOSI ( ALMORA ) Uttarakhand

## INCOME & EXPENDITURE A/C FOR THE YEAR ENDED 31st MARCH, 2010

| PARTICULARS | SCHEDULE | CURRENT YEAR | PREVIOUS YEAR |
|---|---|---|---|
| **INCOME** | | | |
| Income from Sales/Services | **12** | 216376.00 | 207851.00 |
| Grants/Subsidies(net off exp) | **13** | 115572356.75 | 112847390.5 |
| Fees/Subscriptions | **14** | 0.00 | 0.00 |
| Income tfr from Fixed Assets fund (to the extent of depreciation & WDV of asset sold) | **-** | 19023565.61 | 17110095.83 |
| Income from Royalty,Income from Inv. Publication etc. | **16** | 220.00 | 295.00 |
| Interest Earned | **17** | 1451676.00 | 1994486.59 |
| Other Income | **18** | 2481805.00 | 2068148.00 |
| Increase (decrease) in stock of Finished goods and work in progress) | **19** | 0.00 | 0.00 |
| **T O T A L (A)** | | **138745999.36** | **134228266.92** |
| **EXPENDITURE** | | | |
| Establishment Expenses: a) Institute | **20** | 50503939.00 | 50548909.00 |
| b) Projects | | 7974548.00 | 7251892.00 |
| c) F.C (Projects) | | 875069.00 | 685111.00 |
| Administrative Expenses : a) Institute | **21** | 34949584.75 | 33503336.50 |
| b) Projects (As per Annexure) | | 12533084.00 | 11676147.00 |
| c) F.C (Projects)(As per Annexure) | | 974782.00 | 962320.00 |
| Expenditure on Grants, Subsidies etc. | **22** | 7761350.00 | 8219675.00 |
| Interest | | | 0.00 |
| Depreciation (Net Total at the year-end-as per Sch. 8) | | 19023565.61 | 17110095.83 |
| **T O T A L (B)** | | **134595922.36** | **129957486.33** |
| **Balance being excess of Income over Expenditure (A - B)** | | | 4270780.59 |
| Transfer to special Reserve | | | **0.00** |
| Transfer to/ from General Reserve | | | **0.00** |
| **BAL.BEING SURPLUS TRF.TO CORPUS/CAPITAL FUND** | | **4150077.00** | **4270780.59** |
| SIGNIFICANT ACCOUNTING POLICIES | **24** | | |
| CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS | **25** | | |

**AUDITOR'S REPORT**
**As per our separate report of even date annexed.**
**FOR: ANSUL AGRAWAL & CO.**
**CHARTERED ACCOUNTANTS**

**Sd/-**
**(CA. ANSUL AGRAWAL )**
**PARTNER**
**M No.** 092048

**DATED: 23.08.2010**
**PLACE: ALMORA**

**Sd/-**
(DR. L.M.S. PALNI)
**DIRECTOR**

**Sd/-**
(Dr. S.C.R. Vishvakarma)
**D.D.O**

**Sd/-**
(K.K. Pande)
**Finance Officer**

**SEAL**

**G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT**
**KATARMAL, KOSI ( ALMORA ) Uttarakhand**

## RECEIPTS & PAYMENTS A/C FOR THE YEAR ENDED 31st MARCH, 2010

| RECEIPTS | CURRENT YEAR | PREVIOUS YEAR | PAYMENTS | CURRENT YEAR | PREVIOUS YEAR |
|---|---|---|---|---|---|
| **I. Opening Balances** | | | **I. EXPENSES** | | |
| a) Cash in hand | 175983.09 | 60228.90 | **a) Establishment Expenses** | 39821523.00 | 35343127.77 |
| | | | **I) Institute** | | 0.00 |
| b) Bank Balances | | | **b) Administrative expenses** | | |
| | | | a)Institute | 26693548.00 | 18951661.50 |
| i) In current accounts | 12207958.84 | 5106946.12 | b)R&D( Rev) expenses | 12474061.00 | 14353301.00 |
| ii) In deposit accounts | 26920216.48 | 14301869.00 | c) Payments for current liabilities (gratuity/leave) | 213199.00 | 2004670.00 |
| iii) Savings accounts | 17868236.48 | 24929601.18 | **C. Capital expenditure** | | |
| c) Advances & Others | 50080885.65 | 29950992.60 | a) Purchase of Fixed Assets | 17901846.00 | 15392302.25 |
| (As per annexure Attached) | | | b)Expenditure on Capital Work in Progress | 3819700.00 | 10000000.00 |
| **F.C. ACCOUNT** | | | c) Aquirement of land (Lease money) | 0.00 | 172000.00 |
| A) Cash in hand | 6439.33 | 6439.33 | **II Payments made against funds for various proj.** | | 0.00 |
| b) Cash at bank | 907187.67 | 465491.67 | **Expenditure State govt. projects** | | |
| c)FC Advances | 0.00 | 0.00 | a) Capital | 4642304.00 | 3910135.00 |
| **II. Grants Received** | | | b) Revenue; | | |
| a) From Government of India | | | Establishment exp | 7659217.00 | 6455104.00 |
| i) Institute | 91470291.00 | 79559465.00 | Administration exp | 12499599.00 | 11664349.00 |
| ii) IERP Projects | 8500000.00 | 8500000.00 | **Expenditure FC projects** | | |
| b) From Other agencies | 28621302.00 | 27669119.00 | **a) Capital** | 0.00 | 0.00 |
| c) From other sources [from FC] | 5475560.57 | 1962244.00 | **b) Revenue:** | | |
| **III. Income on Investments from** | | | Establishment exp | 843980.00 | 685111.00 |
| | | | Administration exp | 974782.00 | 962320.00 |
| a) Corpus Fund | 2476504.00 | 2183967.00 | **IERP grant released** | 7761350.00 | 8219675.00 |
| | | | **III Investments and deposits made** | | |
| **IV. Interest Received** | | | | | |
| a) On Bank deposits savings a/c | 1159524.00 | 1490206.59 | a) Corpus Fund | 631016.00 | 2183967.00 |
| b)On term deposits a/c | 0.00 | 220546.00 | | | |
| b) Loans, Advances etc. | 289224.00 | 283734.00 | **IV Refund of Surplus money/Loans** | | |
| | | | a) To the Government of India | 241169.00 | 563119.00 |
| **V. Other Income** | | | b)To Others/ security/ caution money) | 367193.00 | 226100.00 |
| | | | **V Other payments** | | |
| (As per annexure Attached) | 2723957.00 | 2276294.00 | Other Payment to Instt. FC Proj. | | |
| **VI. Amount Borrowed** | | 0.00 | Current liabilities | 3324013.44 | 30869213.62 |
| **VII. Any other receipts.** | 286552.00 | | **VI Closing balances** | | |
| b) Advance FC a/c | | 0.00 | **a) Cash in hand** | 35553.49 | 175983.09 |
| c) receipts current liabilities | 3334851.68 | 36615823.29 | **b) Bank Balance** | | |
| d) IERP grants refunded by grantee Org. | 805779.00 | 340877.00 | I) In Current account | 11502199.80 | 12207958.84 |
| e)Construction Fund | | 10000000.00 | ii) In deposit accounts | 29396720.48 | 26920216.48 |
| f) Corpus Fund FDR'S | 24830235.00 | 24199219.00 | III) In savings accounts | 37756130.41 | 17868236.48 |
| g) Caution Money | 2500.00 | | **C) Advances and others** | 56292508.77 | 50080885.65 |
| h) Security Deposit | 18500.00 | | **FC Project** | | |
| | | | a) Cash in hand | 10321.33 | 6439.33 |
| | | | b) Bank Balance | 3299753.07 | 907187.67 |
| **TOTAL** | **278161687.79** | **270123063.68** | **TOTAL** | **278161687.79** | **270123063.68** |

**AUDITOR'S REPORT**
**As per our separate report of even date annexed.**
**FOR: ANSUL AGRAWAL & CO.**
**CHARTERED ACCOUNTANTS**

**Sd/-**
**(CA. ANSUL AGRAWAL )**
**PARTNER**
**M No.** 092048
**DATED: 23.08.2010**
**PLACE: ALMORA**

**SEAL**

**Sd/-**
(DR. L.M.S. PALNI)
**DIRECTOR**

**Sd/-**
(Dr. S.C.R. Vishvakarma)
**D.D.O**
**Sd/-**
(K.K. Pande)
**Finance Officer**

# G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
# KATARMAL, KOSI ( ALMORA ) Uttarakhand

## ANNEXURE FORMING PART OF RECEIPT/PAYMENTS A/C AS ON 31st MARCH, 2010
## STATEMENT OF OPENING & CLOSING BALANCES

| PARTICULARS | OPENING AMOUNT | CLOSING AMOUNT |
|---|---|---|
| **Cash & Bank Balances** | | |
| **Cash In Hand :** | | |
| Srinagar | 1.85 | 5299.85 |
| Sikkim | 3083.00 | 1429.00 |
| Kullu | 390.36 | 60.36 |
| Itanagar | 19577.16 | 22378.16 |
| Grant in aid in transit (Biotech-XIII) | 184000.00 | 184000.00 |
| Cheque in transit: ( Sikkim Unit ) | 0.00 | 17607.00 |
| **Cash at Bank Balances** | | |
| SBI Almora A/c No.10861378091 (Corpus) | 54499.48 | 56423.48 |
| SBI Tadong A/c No 11226047758 | 1295128.00 | 1490154.17 |
| SBI Kullu A/c NO. 10792147561 | 2178799.82 | 1391636.82 |
| SBI Itanagar A/c No 10940060114 | 572274.63 | 3966888.63 |
| SBI Srinagar A/c No 10972182864 | 862179.53 | 686006.53 |
| **Advances** | | |
| House Building Advance | 3182691.00 | 2656443.00 |
| Motor cycle/Car Advance | 374186.00 | 250903.00 |
| Festival Advance | 15000.00 | 21600.00 |
| C.P.F | 36.00 | 36.00 |
| Income tax deducted at source | 191498.00 | 191498.00 |
| **Units of Institute:** | | |
| Sikkim Unit | 0 | -33518.23 |
| HP Unit | -52662.18 | -220840.00 |
| Garhwal Unit | -401924.00 | 16123.00 |
| NE Unit | -83873.00 | 0.00 |
| **FC Advances:** | | |
| ET & NT Delhi(INDO SUMMER) | 2880.00 | 2880.00 |
| NRSA Hyderabad (PARADYP) | 258720.00 | 258720.00 |
| Kasar Jungle Resort (Kailash Workshop) | 0.00 | 25000.00 |
| Kalmatiya Sangam (Kailash Workshop) | 0 | 50000.00 |
| **Fixed Deposit** | | |
| Corpus Fund FDR'S | 24199219.00 | 24830235.00 |
| Interest Accrued on Corpus fund FDR | 2666498.00 | 4510062.00 |
| **FDR (Margin Money/LC A/C)** | | |
| Institute | 2805057.00 | 251364.00 |
| BIOTECH -XI | 577.00 | 577.00 |
| ISRO-JCK (HP Unit) | 1600000.00 | 815000.00 |
| DST Rinu -K Project | 0.00 | 450000.00 |
| DST-JCK-HP Unit | 0.00 | 3445000.00 |
| **TOTAL** | **39927836.65** | **45342966.77** |

# G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
# KATARMAL, KOSI ( ALMORA ) Uttarakhand

| | | | |
|---|---|---|---|
| | **Brought forward** | **39927836.65** | **45342966.77** |
| **Due Staff/ other IC A/c** | | | |
| Dr. Vineeta Jagtap | | 0.00 | 4000.00 |
| Post Master G.P.O Tadong (Sikkim) | | 2154.00 | 213.00 |
| Post Master G.P.O Almora | | 21634.00 | 40566.00 |
| Employment News | | 48287.00 | 48287.00 |
| Sigma Aldrich Chemicals | | 10590.00 | 10590.00 |
| Siltap Chemicals Ltd (Biotech -III) | | 408.00 | 408.00 |
| NRSA Hyderabad | | 35300.00 | 35300.00 |
| R.K.Nanda & Sons | | 28517.00 | 28517.00 |
| NICSI New Delhi | | 35106.00 | 35106.00 |
| B S N L Banglore | | 2912596.00 | 2912596.00 |
| Security Deposit CET Sikkim Unit | | 11000.00 | 11000.00 |
| Uttranchal Renewal (UREDA) | | 165000.00 | 165000.00 |
| Dr. S.C. Joshi (TA) | | 10000.00 | 0.00 |
| NRSA Hyderabad (ISRO GBP SSS) | | 350000.00 | 350000.00 |
| NRSA Hydrabad (DST-KK-I) | | 7400.00 | 7400.00 |
| F.C.Inter A/C | | 2500.00 | 2500.00 |
| M/s CCU New Delhi | | 70898.00 | 70898.00 |
| M/sAnton Par GMBH Australia | | 285909.00 | 0.00 |
| Security Deposit NE Unit | | 1750.00 | 1750.00 |
| M/s Delta T-Devicies, England | | 101150.00 | 46881.00 |
| M/s Bajrang Motors, Haldwani | | 1000000.00 | 0.00 |
| EE, CCU (Servicing of Sub station) | | 854000.00 | 854000.00 |
| NCADMS, Itanagar (MOE&F CC-II) | | 611411.00 | -82270.00 |
| N.E. Regional Institute, Itanagar (MOE&F CC-II) | | 611411.00 | 611411.00 |
| M/s Solar Lite Co. USA (ISRO-GBP EO PRL-JCK) | | 1069133.00 | 0.00 |
| EE R.E.S. Almora (MOE&F (BG) RSR | | 1600000.00 | 2952000.00 |
| EE R.E.S. Almora Insitute | | 0.00 | 1107855.00 |
| MOE&F (S. Sharma) NRSA Hyderabad | | 147000.00 | 147000.00 |
| WWF New Delhi (UNDP-CEF-GOL) NE Unit | | 0.00 | 931823.00 |
| Director State Forest Research Institute ( UNDP-CEF-GOL) NE Unit | | 0.00 | 656711.00 |
| M/S Kipprozones B.V. Netherland | | 159895.00 | 0.00 |
| | **T O T A L** | **50080885.65** | **56292508.77** |

# G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
# KATARMAL, KOSI ( ALMORA ) Uttarakhand

## SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31st MARCH, 2010

### SCHEDULE 8 - FIXED ASSETS

**(DETAILS AS PER ANNEXURE ATTACHED)**

| SR. NO. | DESCRIPTION | GROSS BLOCK | | | | DEPRECIATION | | | | NET BLOCK | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cost as at beginning of the year | Additions during the year | adj/ deduction during the year | Cost at the end of the year | depreciation for prior periods | depreciation for current year | adj/deduction for previous years | Total up to the end of the year | As at the current Year end | As at the previous year-end |
| | **A. FIXED ASSETS:** | | | | | | | | | | |
| | | | | | | | | | | | |
| 1 | **LAND:** | | | | | | | | | | |
| | a) Freehold | 75639.23 | 0.00 | 0.00 | 75639.23 | 0.00 | 0.00 | 0.00 | 0.00 | 75639.23 | 75639.23 |
| | b) Leasehold | 0.00 | 4069026.00 | 0.00 | 4069026.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4069026.00 | 0.00 |
| | | | | | | | | | | | |
| 2 | **BULDING:** | | | | | | | | | | |
| | a) On Freehold Land | 214751988.00 | 0.00 | 0.00 | 214751988.00 | 22683802.01 | 3500457.40 | 0.00 | 26184259.41 | 188567728.59 | 192068185.99 |
| | | | | | | | | | | | |
| 3 | **PLANT MACHINERY & EQUIPMENT** | | | | | | | | | | |
| | a) Scientific Equipments | 145155984.11 | 10288907.00 | 0.00 | 155444891.11 | 58442819.65 | 7359864.28 | 0.00 | 65802683.93 | 89642207.18 | 86925939.83 |
| | | | | | | | | | | | |
| 4 | **VEHICLES** | 6456175.25 | 2492562.00 | 0.00 | 8948737.25 | 4888331.32 | 921120.02 | 0.00 | 5809451.34 | 3139285.91 | 1567843.94 |
| 5 | **FURNITURE FIXTURES** | 20229157.40 | 2271307.00 | 0.00 | 22500464.40 | 11349579.95 | 1424054.04 | 0.00 | 12773633.99 | 9726830.41 | 8879577.46 |
| 6 | **OFFICE EQUIPMENT** | 12139803.35 | 7280479.00 | 0.00 | 19420282.35 | 5797495.52 | 1844926.82 | 0.00 | 7642422.34 | 11777860.01 | 6342307.83 |
| 7 | **ELECTRICAL INSTALLATION** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | **FIRE FIGHTING EQUIPMENTS** | 60962.00 | 0.00 | 0.00 | 60962.00 | 37644.05 | 2895.70 | 0.00 | 40539.75 | 20422.26 | 23317.96 |
| 9 | **LIBRARY BOOKS** | 72695508.75 | 6977096.75 | 0.00 | 79672605.50 | 27116386.81 | 3784448.76 | 0.00 | 30900835.57 | 48771769.93 | 45579121.95 |
| 10 | **TUBE WELLS & W. SUPPLY** | | | | | | | | | | |
| 11 | **OTHER FIXED ASSETS** | | | | | | | | | | |
| | GLASS / NET HOUSE | 3911549.00 | 0.00 | 0.00 | 3911549.00 | 2351401.11 | 185798.58 | 0.00 | 2537199.69 | 1374349.31 | 1560147.89 |
| | | | | | | | | | | | |
| | **TOTAL OF CURRENT YEAR** | **475476767.09** | **33379377.75** | **0.00** | **508856144.84** | **132667460.42** | **19023565.61** | **0.00** | **151691026.03** | **357165118.81** | **343022082.08** |
| | **PREVIOUS YEAR** | **456174329.84** | **19302437.25** | **0.00** | **475476767.09** | **115344589.19** | **17110095.83** | **0.00** | **132454685.01** | **343022082.08** | **343022082.08** |
| | **B CAPITAL W I P** | | | | | | | | | | |
| | **Aquirement of land (Lease money)** | 4021026 | 48000.00 | 4069026 | 0.00 | 0.00 | 0 | 0 | 0 | 0.00 | 4021026.00 |
| | **CCU Delhi** | 44680426.00 | 3819700.00 | | 48500126.00 | 0.00 | 0.00 | 0.00 | 0.00 | 48500126.00 | 44680426.00 |
| | ASSET UNDER INSTAL/TRANSIT | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | | | | | | |
| | **T O T A L** | **520157193.09** | **37247077.75** | **4069026.00** | **557356270.84** | **132667460.42** | **19023565.61** | **0.00** | **151691026.03** | **405665244.81** | **391723534.08** |
| | | | | | | | | | | | |

**SEAL**

# INSTITUTE SUPPORTING STAFF

## HEAD QUARTERS

| | |
|---|---|
| K.K. Pande | Finance Officer |
| Surya Kant Langayan | Accounts Officer |
| L.M.S. Negi | Office Superintendent (Admn.) |
| Sanjeev Higgins | Technical Gr. – III(2) |
| Mritunjay Anand | Technical Gr. – IV(1) |
| Sarita Bagdwal | Stenographer |
| Jagdish Kumar | Stenographer |
| Mamta Higgins | U.D.C. |
| Heera Singh | U.D.C. |
| K.K. Pant | U.D.C. |
| Hema Pandey | U.D.C. |
| S.K.Gurani | L.D.C. |
| Suraj Lal | L.D.C. |
| Jagdish Singh Bisht | Technical Gr. – II(1) |
| R.C.Bhatt | Driver |
| Chandra Lal | Driver |
| K.N.Pathak | Technical Gr. – I(3) |
| Pan Singh | Peon |
| G.D.Kandpal | Peon/Mali |
| Nathu Ram | Peon/Mali |
| Ganga Joshi | Peon |
| Kanshi Ram | Peon/Mali |

## GARHWAL UNIT

| | |
|---|---|
| D.P. Kumeri | L.D.C. |
| M.P. Nautiyal | Driver |
| J.M.S. Rawat | Driver |
| R.C. Nainwal | Field Assistant |
| R.P. Sati | Peon |

## HIMACHAL UNIT

| | |
|---|---|
| S.P. Maikhuri | Office Superintendent |
| Daulat Ram | Peon |

## SIKKIM UNIT

| | |
|---|---|
| R.K. Das | L.D.C |
| Jagnnath Dhakal | Technical Gr. – I(3) |
| P.K. Tamang | Technical Gr. – I(3) |
| Musafir Rai | Peon |
| Shyambir | Peon |

# ABBREVIATIONS

| | |
|---|---|
| NIDM | National Institute of Disaster Management |
| DST | Department of Science and Technology |
| PRA | Participatory Rural Appraisal |
| IHR | Indian Himalayan Region |
| ES | Ecosystem Services |
| EIA | Environmental Impact Analysis |
| MW | Mega Watt |
| NTPC | National Thermal Power Corporation |
| AAQ | Ambient Air Quality |
| SWM | Solid Waste Management |
| MCls | Municipal Councils |
| BC | Black Carbon |
| AOD | Aerosols Optical Depth |
| MWR | Multi-Wavelength Radiometer |
| IST | Indian Standard Time |
| TSP | Total Suspended Particulate |
| LDA | Lake Development Authority |
| TEK | Traditional Ecological Knowledge |
| PNGOs | Partner non –Government Organizations |
| HSCs | Hirb Shoja Catchments |
| CRKA | Chailchowk Rohanda Kamarunga Area |

# INSTITUTE FACULTY

## HEAD QUARTERS

| | | |
|---|---|---|
| L.M.S Palni | Director | Plant Physiology; Biochemistry; Biotechnology |
| P.P.Dhyani | Scientist-G | Plant Physiology; Restoration Ecology |
| Kireet Kumar | Scientist-F | Environmental Engineering; Hydrology |
| S.K. Nandi | Scientist-F | Plant Physiology; Biochemistry |
| R.C. Sundriyal | Scientist-F | Plant Ecology; Rural Ecosystems |
| D.K. Agrawal | Scientist-E | Soil & Water Conservation Engg; Impact Assessment |
| Anita Pandey | Scientist-E | Microbiology |
| S.C.R. Vishvakarma | Scientist-E | Plant Ecology; Rural Ecosystems |
| B.P. Kothyari | Scientist-E | Plant Pathology; Restoration Ecology |
| D.S. Rawat | Scientist-E | Settlement Geography; Rural Ecosystems |
| R.S. Rawal | Scientist-E | High Altitude Ecology; Conservation Biology |
| G.C.S. Negi | Scientist-D | Forest Ecology; Watershed Management; EIA |
| R.C. Prasad | Scientist-D | Library & Information Science; Documentation |
| Subrat Sharma | Scientist-C | Agroecology; Remote Sensing / GIS |
| I.D. Bhatt | Scientist-C | Plant Physiology; Phytochemistry |
| R.K. Singh | Scientist-C | Information Technology |
| A.K. Sahani | Scientist-C | Social Science; Anthropology |
| Rajesh Joshi | Scientist-C | Mathematical Modeling |
| K.C. Sekar | Scientist-C | Plant Taxonomy; Animal Taxonomy |
| Shilpi Paul | Scientist-C | Molecular Biology; Plant Biotechnology |
| Vasudha Agnihotri | Scientist-B | Soil Science; Plant Analysis; Instrumentation |
| R.G. Singh | Tech. Grade IV (3) | Applied Arts; Photography, Social Science |
| B.S.Majila | Tech. Grade IV (3) | Forest Ecology; Restoration Ecology |
| Subodh Airi | Tech. Grade IV (2) | Forest Ecology; Biotechnology |

## HIMACHAL UNIT

| | | |
|---|---|---|
| S.S. Samant | Scientist-E & In-charge | Plant Taxonomy; Conservation Biology |
| S.C. Joshi | Scientist-E | Plant Physiology; Stress Physiology |
| J.C. Kuniyal | Scientist-D | Development Geography; Waste Management |
| R.K. Sharma | Scientist-C | Policy Analysis; Environmental Management |

## SIKKIM UNIT

| | | |
|---|---|---|
| H.K. Badola | Scientist-E | Morphoanatomy; Conservation Biology |
| K.K. Singh | Scientist-D & In-charge | Plant Physiology; Stress Physiology |
| Varun Joshi | Scientist-C | Environmental Geology |
| Ranjan Joshi | Scientist-C | Ecology Economics; Resource Valuation |
| L.K. Rai | Tech. Grade IV (3) | Plant Taxonomy |
| Y.K. Rai | Tech. Grade IV (3) | Rural Ecosystems |

## GARHWAL UNIT

| | | |
|---|---|---|
| R.K. Maikhuri | Scientist-E & In-charge | Plant Ecology; Rural Ecosystems |
| N.A. Farooquee | Scientist-D | Social Science; Indigenous Knowledge Systems |
| Paromita Ghosh | Scientist-C | Plant Science; Soil Science |
| S. Tarafdar | Scientist-C | Weather & Climate Change; Glaciology; Hydrology |

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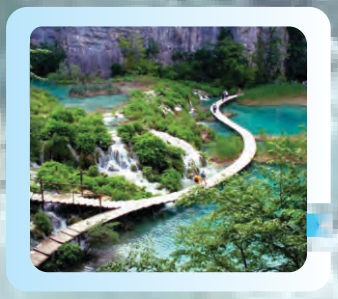
|---|---|---|
| P.K. Samal | Scientist-E & In-charge | Social Science; Anthropology |
| M.S. Lodhi | Scientist-C | Environmental Assessment |
| S.C. Arya | Scientist-B | High Altitude Ecology |
| S. Chaudhary | Tech. Grade IV (2) | Conservation; Biological Diversity |

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**Designed & Printed at Shiva Offset Press, Dehradun Ph. 0135-2715748**